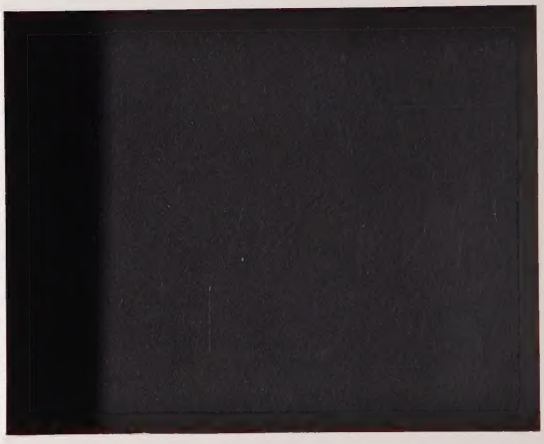
THERMO ELECTRIC

Instruction Manual

Indicating Thermocouple Controller

Model 32442-53045



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Amplifier P.C. Board Assembly (A5782)
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Schematic Diagram
Installation Diagram

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1-0 DESCRIPTION

1-1 Introduction

This manual contains all the information normally required to operate and maintain Indicating Thermocouple Controller Model 32442-53045. Should you require additional information, contact your local Thermo Electric Applications Engineer or our main office in Saddle Brook, New Jersey. We will be happy to be of assistance.

1-2 Application

This instruction manual covers the operation, installation and maintenance of Model 32442-53045 Indicating Thermocouple Controller, (hereinafter referred to as, Controller). For variations on construction refer to the Addendum.

1-3 Description

The Controller is a highly stable,accurate solid state instrument that provides automatic temperature control of a single electrically heated process by utilizing modern integrated circuits. The controller measures the millivolt output of a thermocouple positioned in the process and supplies up to 15 amperes of full wave power (60 Hz) output to maintain process temperature. The temperature level is determined by the operator who adjusts the digital setpoint knob on the front panel Process temperatures within 25°C of the setpoint are continuously read out on an indicating deviation meter above the setpoint scale. The meter is calibrated directly in degrees Celsius.

The maximum available output from start-up until process temperature reaches the proportional band, is constant providing fast warm-up time. When process temperature enters the proportional band, a percentage of output power is decreased linearly from the maximum current available to the minimum. When process temperature equals setpoint level, an optimum output is achieved providing a precise balance between process power input and process heat losses. The automatic reset circuitry corrects for any process load changes. A red signalling lamp above the indicating meter on the front panel illuminates to indicate power to the controller.

Controller Model 32442-53045 is equipped with High and Low Alarm. High and Low alarm provides the process with a visual indication of an over and under temperature condition. An internal alarm relay provides a set of form "C" contacts, wired to the rear terminal block, TB2, which may be used to start or stop auxiliary equipment should an alarm condition occur. High alarm or Low alarm may be disabled for a broad percentage of span on either side of setpoint by turning the undesired alarm potentiometer fully clockwise or counterclockwise respectively.

Controller Model 32442-53045 is a two mode controller (Proportional + Integral) (See Section 1-5 Proportional Gain and Automatic Reset for explanation of control modes.)

To protect your process, failsafe circuitry decreases the percentage of output power to zero in the event of an open circuited thermocouple.

1-4 Specifications

Measuring Circuitry

Setpoint Accuracy: ±0.5% in the interval of 50 to 220°C
Repeatability: 0.1% of full scale span.
Measuring Circuit: Potentiometeric: solid state throughout
Reference Junction Compensation: Automatic (temperature sensitive resistor at input connector)
Standardization: Continuous (temperature compensated Zener diode constant voltage supply)
Temperature Indication: Temperature deviation meter ±25°C.
External (Sensor) Resistance: 100 ohms maximum. (Special calibration required for resistances up to 500 ohms.)
Standard Input: Thermocouple (see instrument scale for calibration)

Limits for External Conditions

Ambient Temperature: 40 to 120°F (operation), 0 to 150°F (storage)
Input Voltage: Switch selectable. 115 Vac ±10%, 50-60 Hz or 230 Vac ±10%, 50-60 Hz
Common Mode Rejection with 200 ohm input unbalance, DC and AC: 1×10^6, 115 V maximum
Long Term Stability (under constant ambient temperature and constant input line voltage) ±30 microvolts.

Output Characteristics

Output: Triac provides up to 15 amperes at input line voltage to a resistive load.
Proportional Gain: 1 to 100 (100% to 1% proportional band) adjustable from front panel.
Reset: Automatic .01 to 1 minutes per repeat 10 to .1 repeats per minute adjustable from front panel.

Physical Specifications

Case: Ventilated (perforated) sheet steel
Dimensions: 4 3/16" W x 6 1/2" H x 15" D
Weight: Approximately 9 1/2 pounds
Mounting: Flush panel, shelf or table top. Mounts with two concealed screws behind the controller front panel.

1-5 Principles of Operation

The basic elements of model 32442-53045 controller are shown in the block diagram (Figure 1). In operation, the measuring circuit produces a dc error signal which is converted to 2500Hz ac in the modulator circuit then amplified and reconverted to dc by the demodulator circuit. The demodulated and filtered signal then drives an emitter follower. The output of the emitter follower is compared with a fixed reference V2, and the resulting difference voltage drives the deviation meter and differential amplifier A1, and also supplies a reference

Level for the input to the alarm circuit Q25. The output of A1 drives proportional gain amplifier A2. The gain of A2 is adjustable from the front panel and is used to adjust the proportional band. (Proportional gain is 100 times the reciprocal of percent proportional band). The output A2 is supplied to the Reset amplifier (Integrator) and summing amplifier. The Reset amplifier functions are adjustable from the front panel. These two signals are then multiplied by appropriate gain factors and "summed" by amplifier A5. The output of A5 is tied to A1 on PC-1. The other input for A1 is from the ramp generator composed of Q14, Q15, Q16, Q17 and Q18. The output from A1 controls the output firing circuit for the Triac. The output is now a function of reset and proportional gain controls and the ramp function generator.

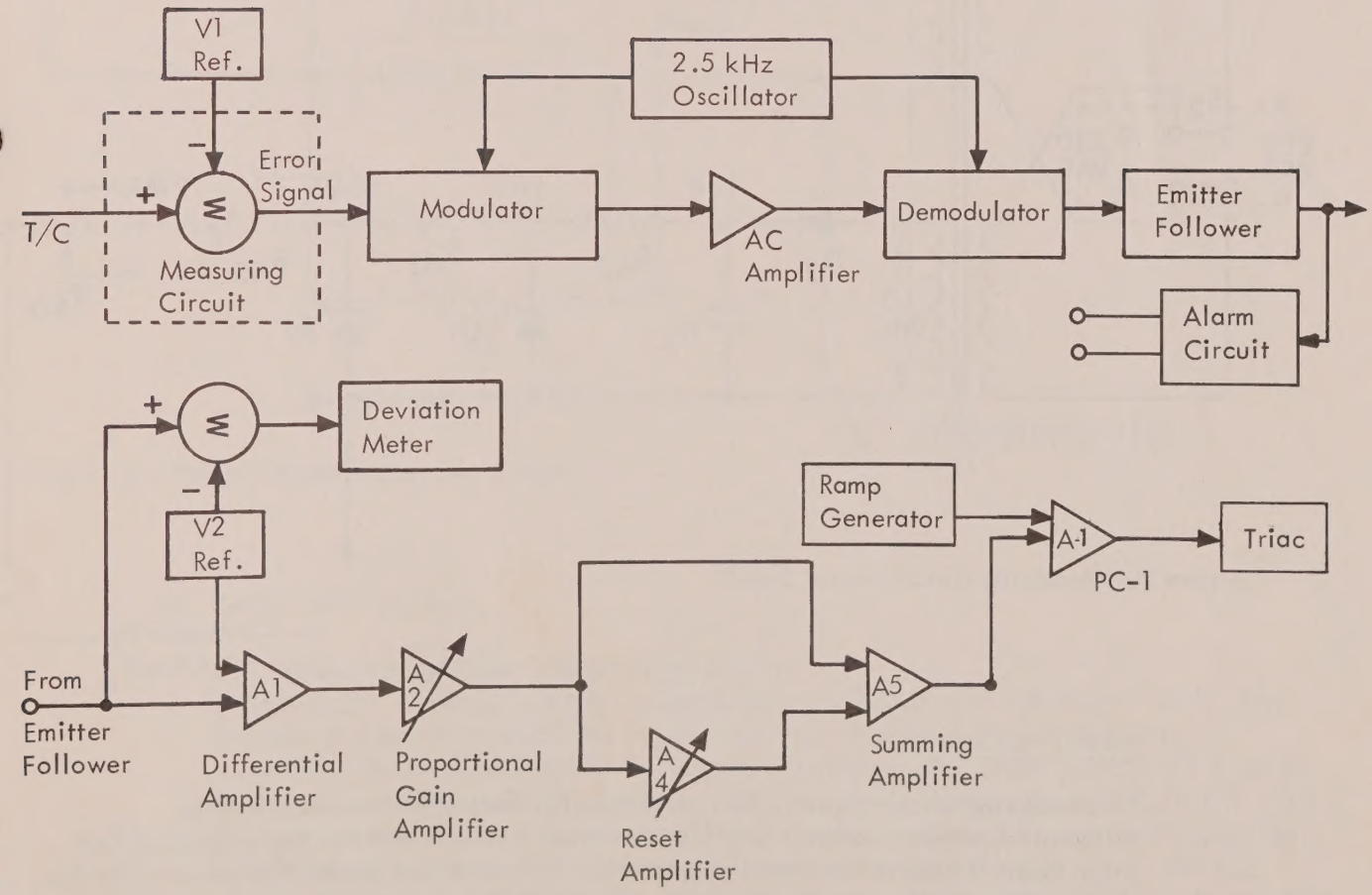


Figure 1 - Block Diagram

Power Transformer T1

The primary winding of the transformer (Figure 2) is capable of receiving either 115 Vac or 230 Vac, 50-60 Hz. Switch S2 located on the controller rear panel provides a parallel arrangement of the transformer windings for receiving 115 volts or a series arrangement for receiving 230 volts. Two secondary windings are provided; one for the amplifier power supply and the other for the measuring circuit power supply.

Measuring Circuit Power Supply

The measuring circuit power supply contains a half-wave rectifier (D2) and filter capacitor C2. The combination of the capacitor and the resistance of the secondary transformer winding provides the desired 50-60 Hz and harmonics filtration.

Regulation is accomplished by Zener diodes Z1 and Z2 in combination with resistors R62 and R61 respectively. Total regulation factor equals 1/8000. Dropping resistor R65 and potentiometer R4 reduce the voltage at Z2 to provide approximately 1.019 volts at 2 mA required by the measuring circuit. (See Section 6-0 "CALIBRATION" for adjustment of R4).

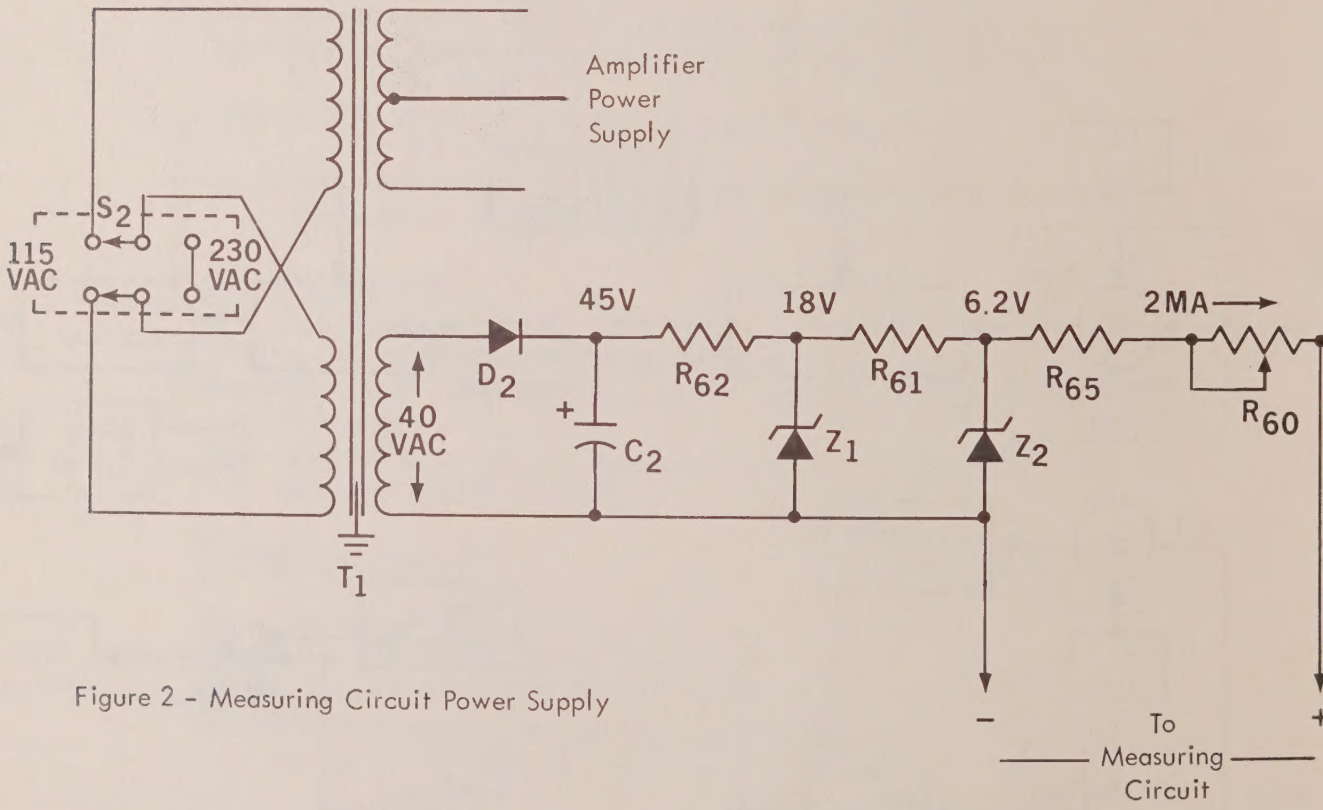


Figure 2 - Measuring Circuit Power Supply

Measuring Circuit

The measuring circuit power supply furnishes a current which causes a voltage differential between points A and B and between points C and E. The voltage picked off at point D adds to the thermocouple emf. This combined potential is opposed by the voltage picked off on the setpoint potentiometer R66. The amplifier and control circuitry use the voltage difference (error signal) created by these opposing voltages to determine control functions.

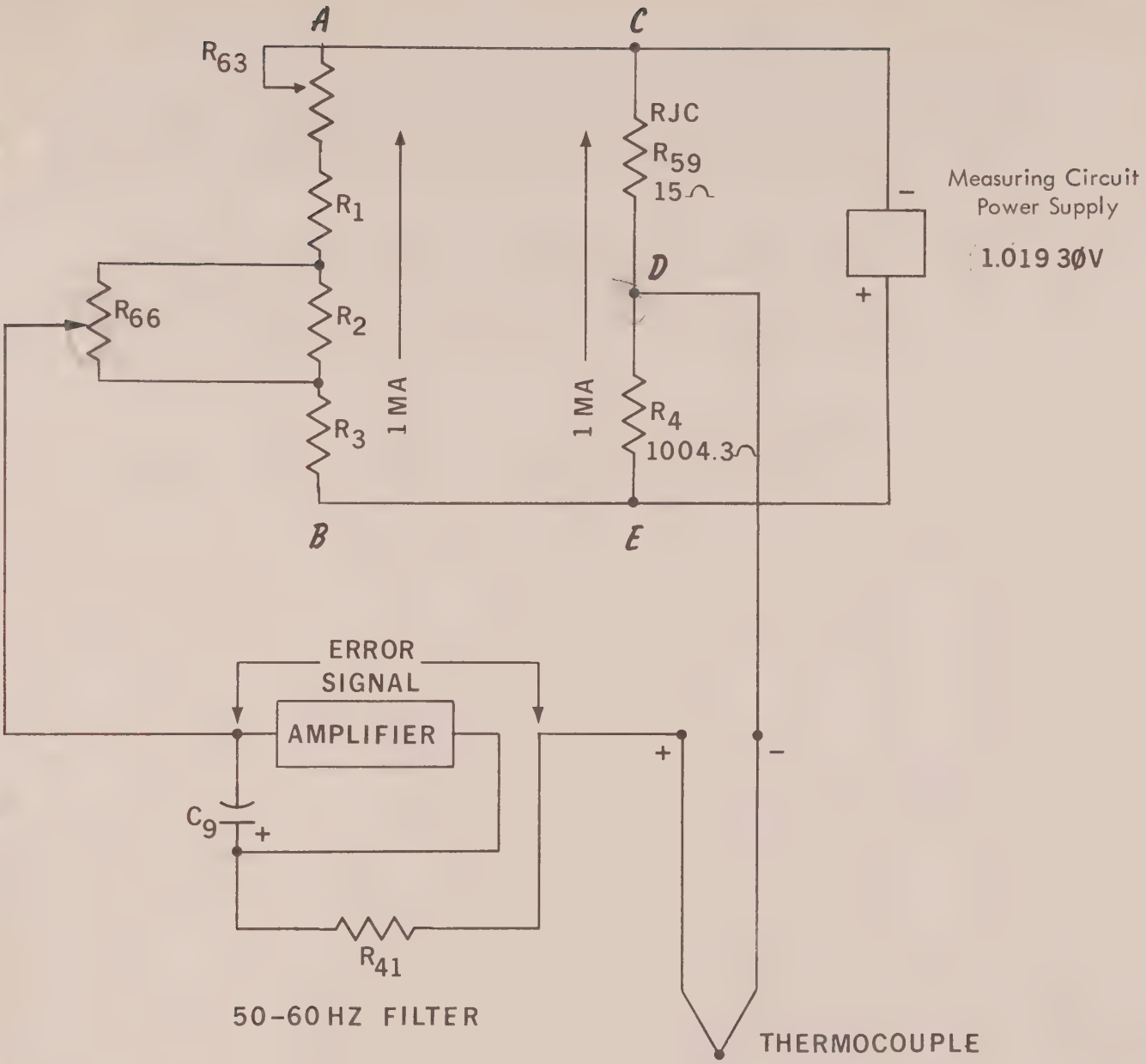


Figure 3 - Potentiometer Measuring Circuit

Component Functions

1. RJC (Reference Junction Compensating Resistor)
Thermocouple reference junction compensation is obtained with RJC resistor R59. This component changes its resistance in proportion to reference junction temperature variations, and thus has a direct effect on the voltage picked off at point D in Figure 3. A rising reference junction temperature, for example, lowers the thermocouple emf. The temperature rise, however, also increases the resistance of the RJC, thus increasing the voltage at point D. Since the voltage at D adds to the thermocouple input, the RJC effectively compensates for the drop in thermocouple emf. In order to insure compensation for the correct reference junction temperature, the RJC resistor is mounted inside the thermocouple connector.

2. Resistors R1, R2, R3, R4 and R101 adjust the span across the slidewire R66 so that the voltages picked off on the slidewire will match the millivolt range of the instrument scale.

3. The zero adjust potentiometer R63 has a dual purpose. First, it provides a convenient method of zeroing the measuring circuit during calibration and corrects for small errors produced by resistance tolerances in the circuit; second, it provides compensation for the operating level of the amplifier and assists in placing the operating point of the amplifier in the midpoint of its linear range.

4. 50/60 Hz Filter

The input filter (R41 and C9) provides the instrument with a normal mode rejection ration of 1×10^3 (See Specifications).

Figure 4 - Not Used

Modulation

The error signal from the measuring circuit is chopped or converted to a 2.5 kHz square wave for amplification. Modulation is achieved by a dual emitter transistor Q8. The transistor is driven by a 2.5 kHz square wave oscillator consisting of two transistors (Q6 and Q7) several resistors and a capacitor, as shown in Figure 5.

Isolation between the oscillator and chopper is accomplished by interstage transformer T3. The error signal is passed for amplification during half of the oscillation cycle and blocked during the other half.

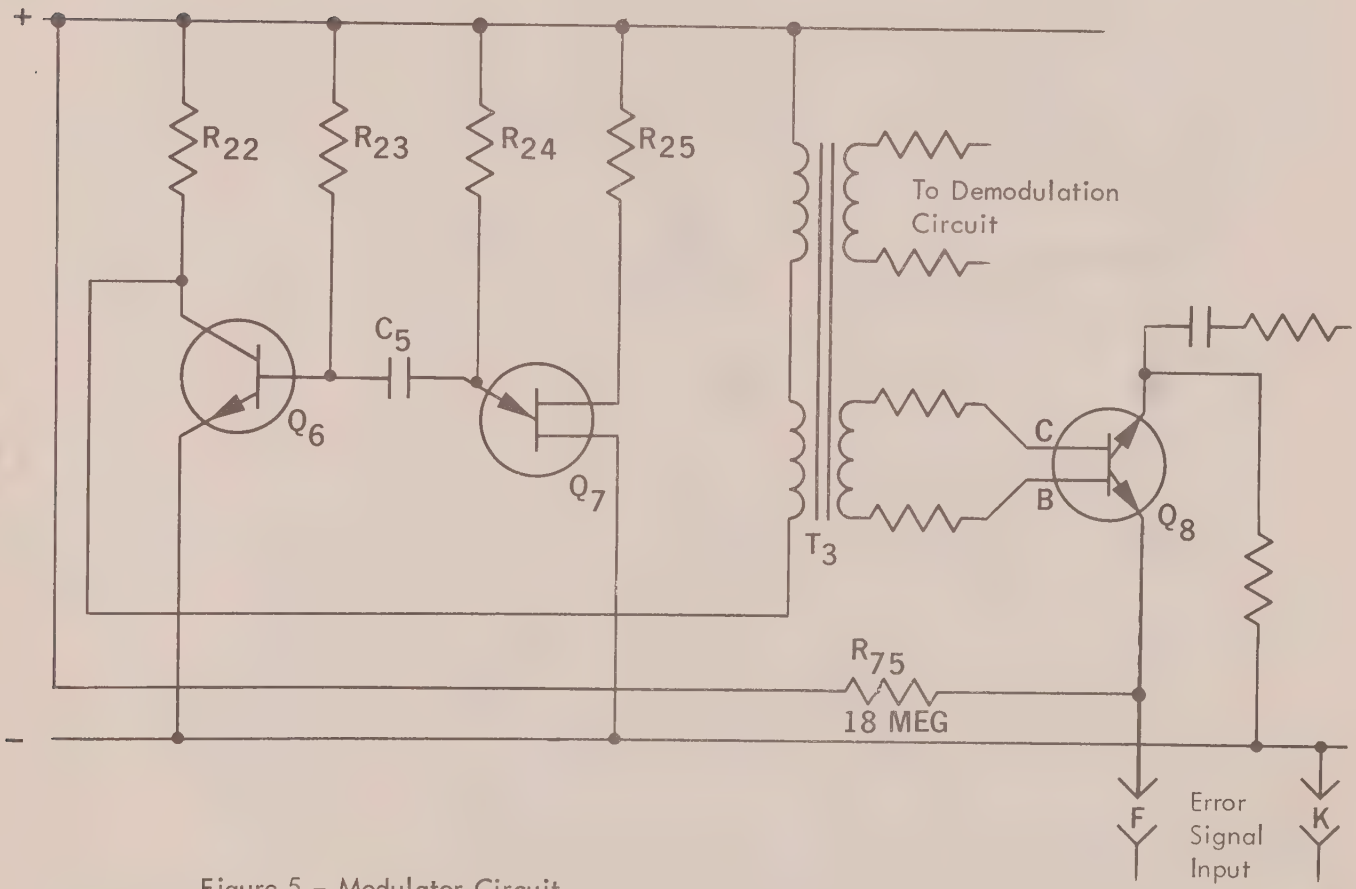


Figure 5 - Modulator Circuit

AC Amplifier

The primary amplifying stage consists of Q9, Q10 and Q11. Feedback resistors are R42, R44, R48 and R33. All three transistors are biased for proper dc level and high stability. The power supply for Q9 is isolated from Q10 and Q11 by means of RC filter R30-C6. Power to Q10 is also isolated from the main supply by RC filter R31-C7.

Input impedance of the amplifier is about 2 k ohms. The amplifier becomes saturated when the dc input signal is approximately ± 2 millivolts. The ac wave form at the output of Q11 is about 10 volts in magnitude at saturation.

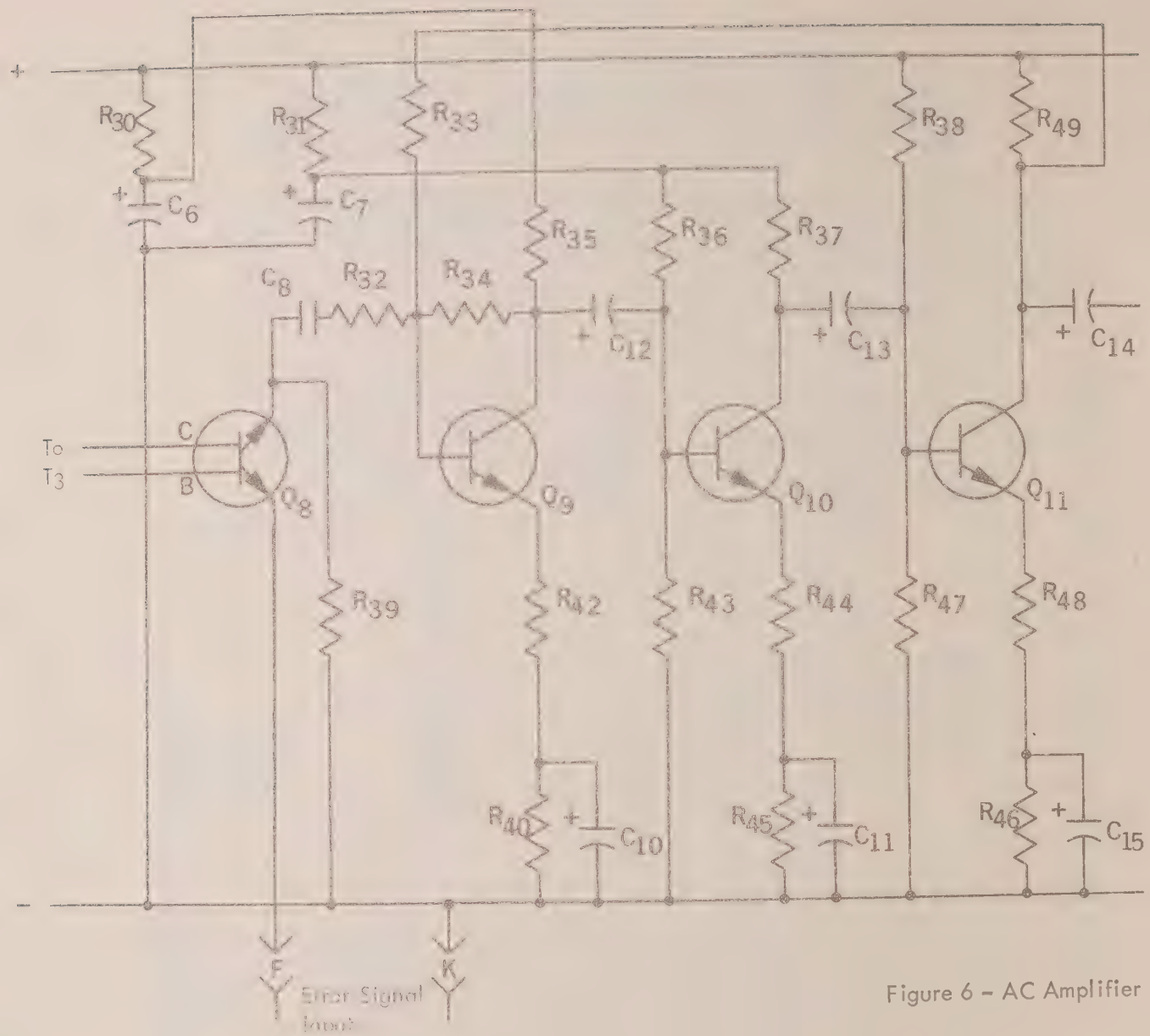


Figure 6 – AC Amplifier

Demodulation

The signal from the collector of Q11 has a frequency of 2.5 kHz and is approximately 1,000 times greater than the dc input signal. Since a dc signal is now required to drive the temperature deviation meter and perform the control functions, the amplified signal from Q11 is demodulated. This is achieved with transistorized chopper Q12.

Q12 is coupled electrically to the remaining secondary of transformer T3 to synchronize demodulation to input modulation. An RC filter consisting of resistor R50 and capacitor C16 rejects high frequency components remaining on the dc signal after demodulation.

DC Amplifier

The dc output signal from the demodulator is connected to the base of emitter follower Q13. Q13 in turn, drives the deviation meter and differential amplifier A1.

Deviation Meter

The meter indicates deviations of process temperature from the setpoint temperature setting. It has a center zero (null) position. With an assumed gain of 1,000, the dc amplifier output is linear with an applied amplifier input signal (measuring circuit error signal) of +1.5 millivolts dc. This +1.5 mV signal corresponds approximately to +100°F for ISA-J calibration thermocouples and +150°F for ISA-T or K thermocouples. The amplified signal output from Q13 is linear between -2 and +4 volts. To guarantee a swing of almost 3 volts in either direction, the 50-0-50 microampere deviation meter must balance when the output from Q13 is approximately 0.8 volts. This is accomplished with the voltage divider R7 and R6 across the amplifier power supply. Potentiometer R21 is used for calibrating the meter for the precise span desired (±100°F).

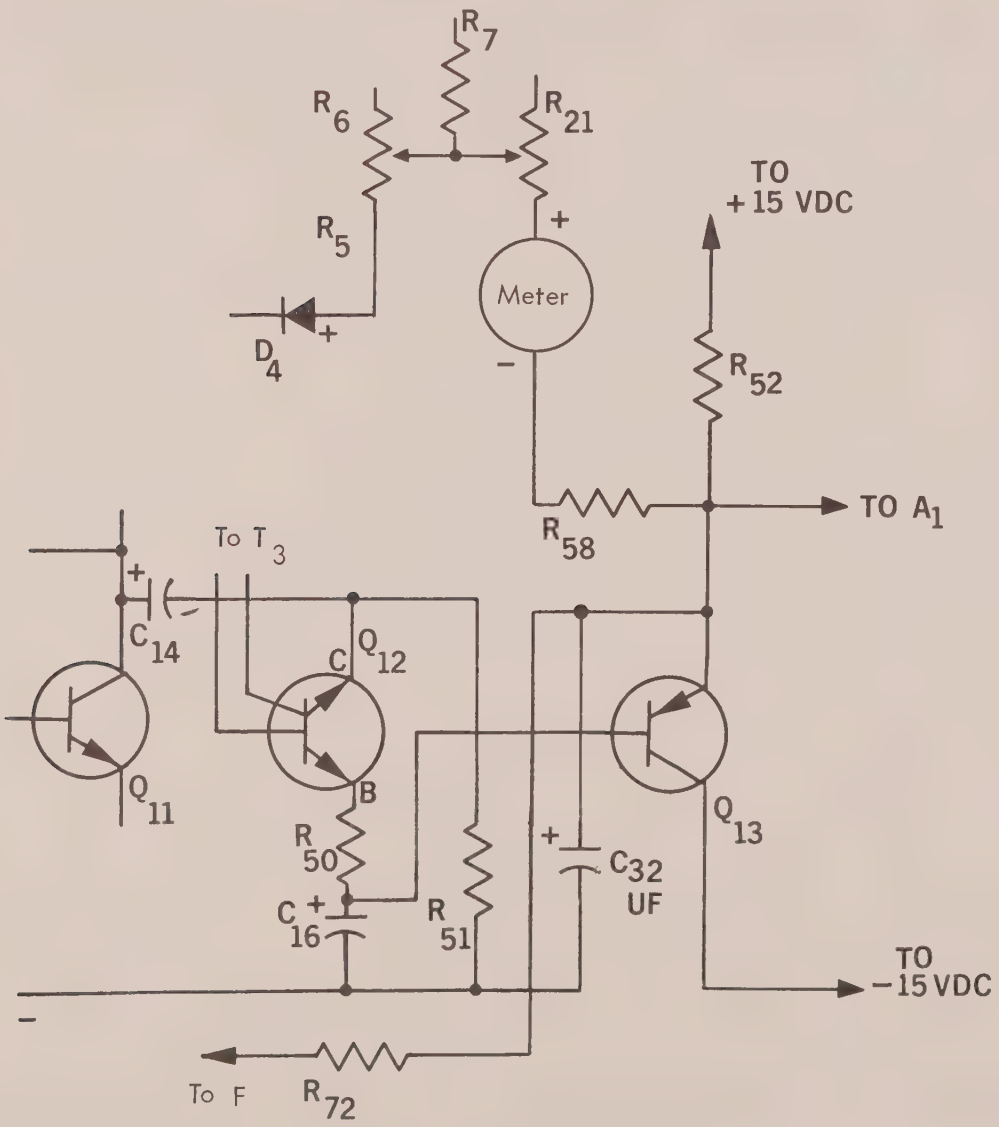


Figure 7 - Demodulation and Meter Circuits

Proportional Gain

Operational amplifier A1 is connected as a differential amplifier with a gain of 2. It receives the signal from the emitter of Q13 and reference voltage V2. This is essentially the signal across the deviation meter. This zero-referenced signal then drives the Proportional Gain amplifier A2. The gain of A2 is adjustable from the front panel. This gain adjust in turn controls the proportional band of the instrument.

Note: Proportional band expressed as a percentage of full scale is defined as the reciprocal of proportional gain times 100.

$$\% \text{ Proportional Band} = \frac{100}{\text{Proportional Gain}}$$

Example: A proportional gain of 4 is equal to a proportional band of 25% of full scale span.

Figure 8 shows the effect of the proportional gain amplifier on the final output of the controller.

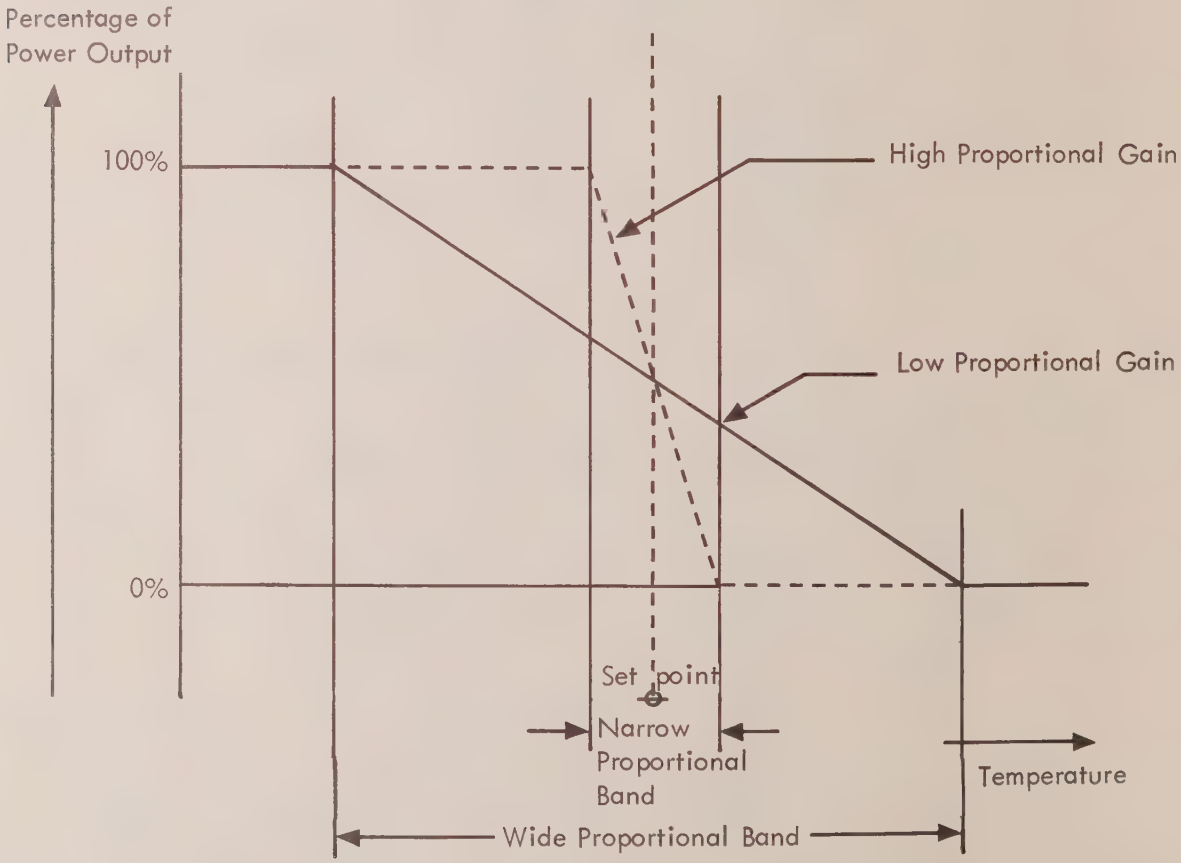


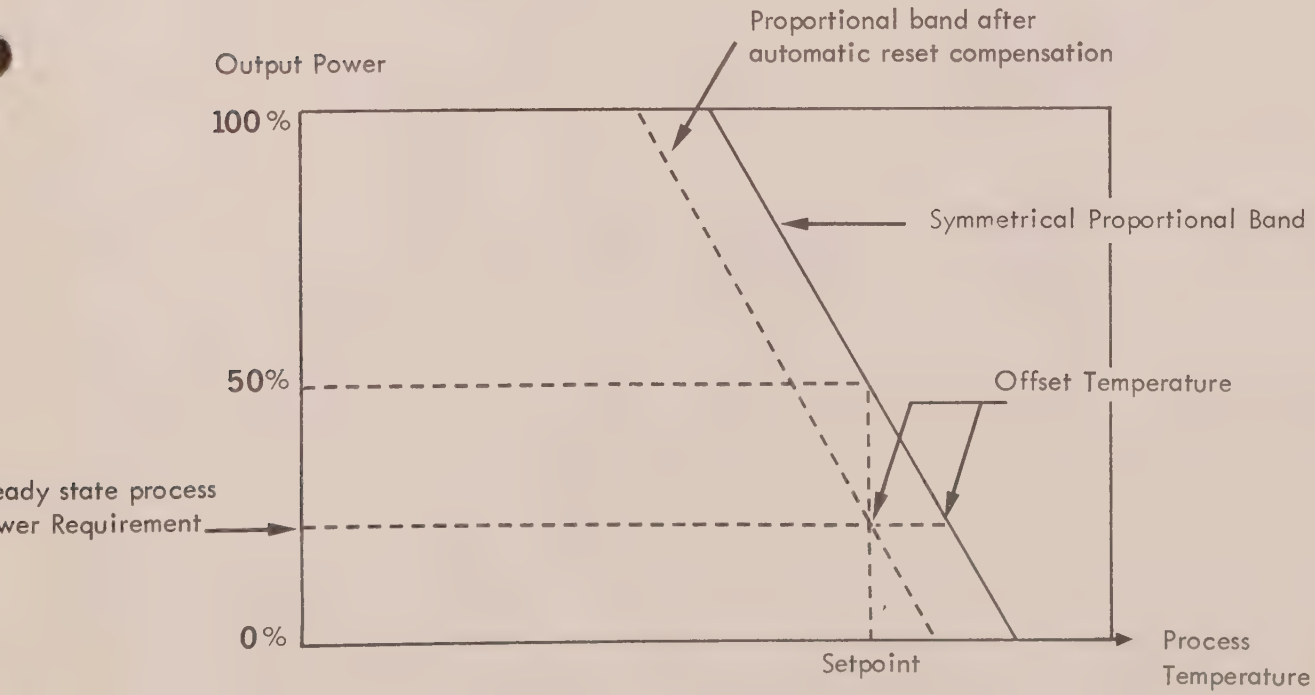
Figure 8 - Proportional Gain Effect on Output of Controller

Automatic Reset (Integral) Action

Assuming that the output of amplifier A2 has already been converted to power output and fed to a process load (Figure 9), it can be seen that the percentage of power supplied at setpoint will not maintain process temperature without an offset unless this occurs coincidentally. Power output to process at setpoint is normally 50% of total

power available in a symmetrical proportional band system. This results in the process being either under or over temperature when the controller is at setpoint, unless the load requirement is exactly 50% of total power available. The automatic reset function integrates the offset voltage with respect to time and thereby "shifts" the proportional band up or down scale until process power is exactly at the point giving zero voltage at amplifier A2.

To achieve automatic reset action, the output of A2 is fed into an integrator (amplifier A4). When the process temperature exactly matches the setpoint temperature, the output of A2 is zero. Whenever a temperature unbalance occurs, A2 produces an output. A4 and its associated input and feedback elements will integrate any nonzero output of A2. A4's output is then multiplied by an appropriate gain factor and added to the output of A2 in such a manner that forces the error between process and setpoint temperatures to zero. The rate at which A4 integrates the output of A2 is adjustable from the front panel and is calibrated in "Minutes per Repeat." This means the amount of time in minutes required for the effective output of the integrator (as seen by the process) to equal the output of A2. Figure 10 depicts proportional gain, automatic reset and rate circuitry. A front panel mounted switch marked "Auto Reset" provides a means for removing the automatic reset circuitry when initiating processes with long heat up times. When depressed, the automatic reset function is operational; when released the automatic reset is inoperative. The automatic reset function should be engaged only as the process nears setpoint temperature.



igure 9 - Effect of Automatic Reset on Process Temperature Offset

High and Low Alarm

The High-Low alarm circuitry derives its signal from the emitter of transistor Q13. This signal is inverted, amplified and used to control two transistors connected to serve as voltage controlled current sources. These transistors control the charging of capacitors C24 and C25 in the high and low alarm trigger circuits. The trigger circuits operate a single silicon controlled rectifier (SCR) which controls the alarm lamp and relay coil. Since the SCR supply is a dc voltage, it will remain in the conducting state until the dc supply is disconnected momentarily. This is accomplished by operating the manual reset switch. Adjustment of the high and low alarm function is accomplished with potentiometers mounted on the front panel. Each instrument is shipped with the alarms set at + 10°F unless otherwise specified. The low alarm trigger point may be adjusted further below setpoint by rotating the low alarm pot counterclockwise. The high alarm trigger point may be adjusted further above setpoint by rotating the high alarm pot clockwise.

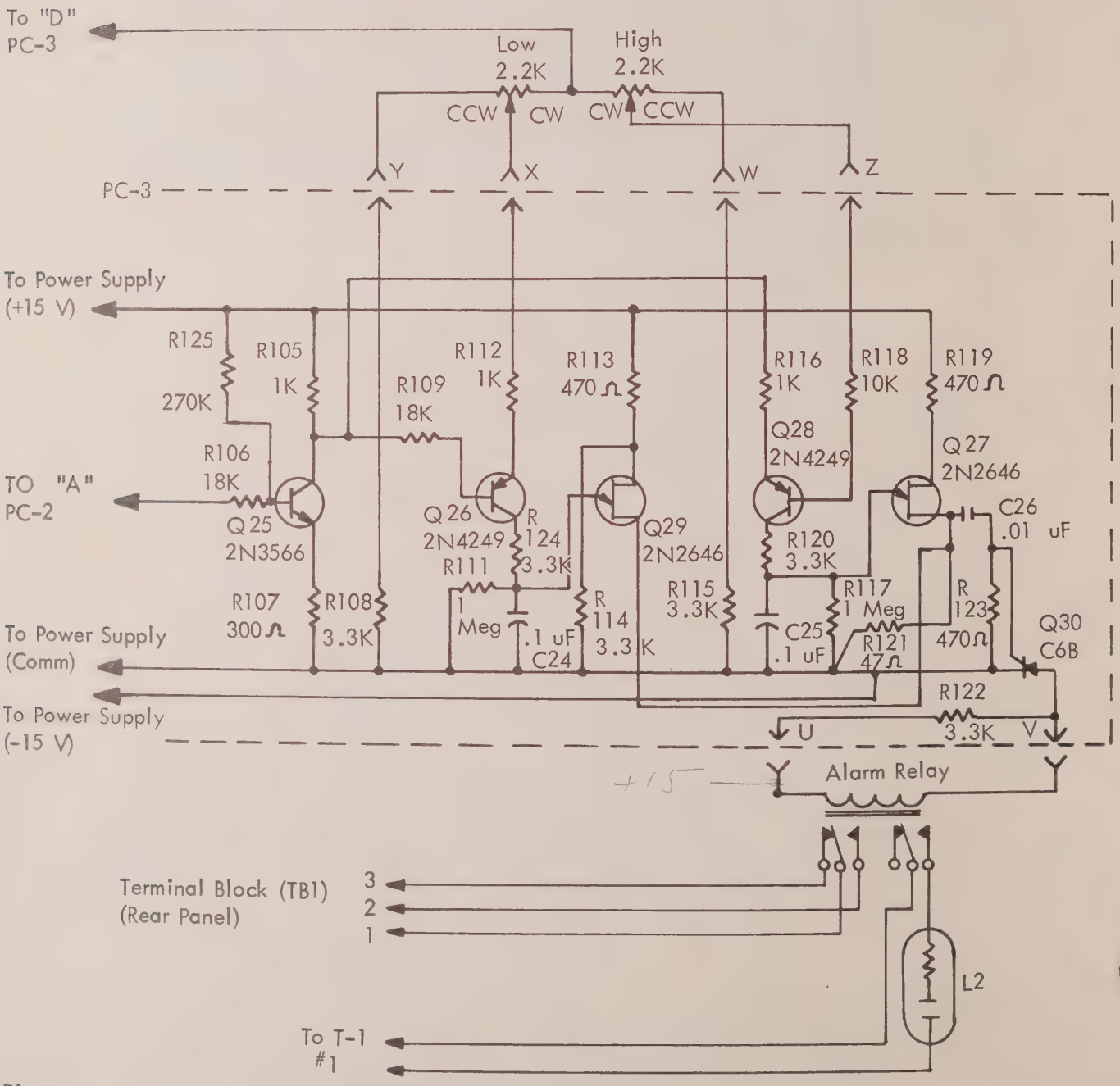


Figure 10 - Schematic Diagram - Alarm Circuit

2-0 INSTALLATION

2-1 Unpacking

Leave the instrument in the shipping container until ready to install. In general, instruments are shipped with small accessory items in the same box. Check all items against the packing list before discarding the shipping container and packing material.

2-2 Location

Install the controller in an area which remains within the ambient temperature limits of 40 to 120°F. If the instrument is to be mounted in a cabinet, prevent possible heat damage to the components by providing adequate ventilation For longest life, locate in room with a dry, clean atmosphere.

2-3 Mounting

The instrument can be mounted in any type of panel with two screws. See dimensioned mounting drawing in the Appendix.

2-4 Electrical Connections

All electrical connections are made to the two terminal blocks located at the rear of the controller. To wire, remove the terminal screw, attach lead and secure terminal screw. Refer to Table I for connection points.

Power Input

The power selector switch mounted on the controller rear panel must be positioned for either 115 or 230 volt operation before energizing the controller. The line cord used to supply the instrument should be capable of carrying 15 amperes for the controller circuitry.

Grounding

Terminal 10 should be grounded in accordance with NEMA standards or equivalent methods. Conduit grounds must be avoided as their potential with respect to a water pipe is frequently high enough to prove detrimental to the performance of the instrument.

Control Wiring

The external current to pressure converter, SCR power controller, etc. should be connected directly to terminal posts 5 and 6 on terminal block TB2

Thermocouple Input

Terminal posts 3 and 4 on TB2 provide the connection point for the thermocouple input.

TABLE I - CONTROLLER EXTERNAL WIRING

Terminal Block - TB1	
Terminal Number	Connect To
1	Low Alarm
2	Common
3	High Alarm

Terminal Block - TB2	
Terminal Number	Connect To
1	External Reset (NC)
2	
3	Thermocouple(negative)
4	Thermocouple (positive)
5	Load
6	Load
7	Power Input (N)
8	Power Input (H)
9	Thermal Inter-Lock
10	Ground

3-0 OPERATING INSTRUCTIONS

3-1 Operating Controls

The Digital Setpoint Knob is used to set the desired process temperature. When adjusting, stand directly in front of the controller.

The Proportional Gain Control is adjustable from 1 to 100 (100% to 1% proportional band). The setting determines the process temperature level at which full power output to the process will gradually begin to decrease in proportion to the difference between process level and setpoint level.

The Automatic Reset Control is used to adjust the time over which integral action occurs. This is the time required for the integrator circuit to repeat a step function change in input. Reset action is adjustable from .01 to 1 minutes per repeat.

The Automatic Reset Switch provides a means for removing the automatic reset circuitry when starting processes with long heat up times. When depressed, the automatic reset function is operational; when released it is inoperative. As a slow heating process nears setpoint, the switch should be depressed.

High and Low Alarm Controls are used to set the high and low alarm potentiometers to a predetermined point where if process temperature exceeds the high alarm or falls below the low alarm setting, an over or under alarm condition exists and a visual indication will be observed on the front panel and alarm relay K1 is enabled.

3-2 Operating Procedures

The instrument is shipped with all parts in place ready for operation. After mounting and making all electrical connections as instructed in Section 2, proceed as follows:

3-3 Preliminary Adjustments

A. Adjust the setpoint scale for the desired process temperature.

B. Rotate the proportional gain control to a maximum clockwise postion. This setting creates the narrowest possible proportional band.

C. Position the reset control at midpoint.

3-4 Start-Up

A. Place the Auto Reset switch in the off (out) position. Energize the controller. Illumination of the red lamp is an indication of applied instrument power. As process temperature rises to within 25°C of setpoint, the indicating meter will begin to move toward center scale.

B. As process temperature nears setpoint, the power output will begin to decrease upon entering the proportional band. Depressing the Auto Reset switch will place the automatic reset into operation. When steady state conditions are realized, process temperature will be maintained with no offset. (Offset is defined as being the error between actual process temperature and setpoint temperature). Note that the Auto Reset may remain in the cirucit at all times for processes with rapid heating times.

C. After process temperature stabilizes, the proportional gain control should be adjusted until temperature cycling is eliminated. This is most easily accomplished by turning the control through a few degrees of rotation and then waiting until the process again stabilizes. The procedure is then repeated until the indicating meter becomes stable.

4-0 PERIODIC MAINTENANCE

No regular maintenance is required.

5-0 TROUBLE SHOOTING

5-1 General

Before attempting trouble shooting procedures, check to see:

A. if the instrument is properly grounded.

B. if all connections are secure and properly made to the two terminal blocks.

D. if the indicating lamp and deviation meter are in operating condition. (The instrument will control properly if either of the former is the only defective component.)

To remove the perforated cover: Remove the single screw located at the top of the rear section and slide the cover straight back.

To remove the printed circuit boards: Grasp the circuit board edges and remove by pulling straight up; do not grasp by components.

5-2 Trouble Shooting Guide

It is assumed that all input and output connections are properly made.

Symptom of Trouble	Possible Causes
Indicator lamp remains off; process cooling. Deviation meter does not indicate (remains at null).	Measure line voltage at rear terminal block (TB2), terminals 7 and 8. Voltmeter indication should agree with setting of slide switch at rear of instrument. Absence of voltage indicates external wiring at fault.
Process overheating; deviation meter indicates an over temperature condition.	Triac shorted.
	Defective printed circuit board component. Replace PC-1 and recheck operation.*
Process cooling; deviation meter indicates an under temperature condition.	Triac open.
	Defective printed circuit board component. Replace one printed circuit board at a time (PC-2, PC-3 or PC-1) rechecking operation after each replacement in order listed.*
No proportional band.	PC-1, PC-2 or PC-3 defective. Replace in order and recheck operation.*
No reset action; deviation meter indicates an offset, process temperature stabilized near setpoint.	Check to see that the Auto Reset switch is depressed.
	PC-3 defective. Replace and recheck operation.*
	Reset control potentiometer defective.
	Reset capacitor C15, A6313 defective.
No meter deviation	PC-1 or PC-2 defective. Replace one printed circuit board at a time rechecking operation after each replacement.* Check for secure connections to meter.
Meter indicates an under temperature condition with no apparent control.	PC-1 defective. Replace and recheck operation.*
Calibration off	See Section 6-0 in this manual for calibration procedures.

*It may be necessary to recalibrate the controller if a printed circuit board or component is replaced. Refer to Section 6-0 for the procedure.

6-0 CALIBRATION AND TESTING

Several methods of calibration are available. The one following will yield highest calibration accuracy. Adjustment potentiometers and voltage reference points can be quickly found by referring to the schematic diagram and the Parts Identification illustrations in the Appendix.

6-1 Calibration

Equipment:

A. Precision laboratory potentiometer

B. Calibrated reference junction thermocouple with copper extension wire for cold simulation.

C. Voltmeter - Simpson 260 or equivalent (2 required)

D. Thermocouple EMF vs. Temperature conversion table, 32°F (0°C) reference temperature.

E. Thermo Electric ICELL or ice bath 32°F (0°C)

F. Stopwatch

G. Tektronics Model 422 or equivalent.

Procedure:

1. Connect equipment as shown in Diagram A.

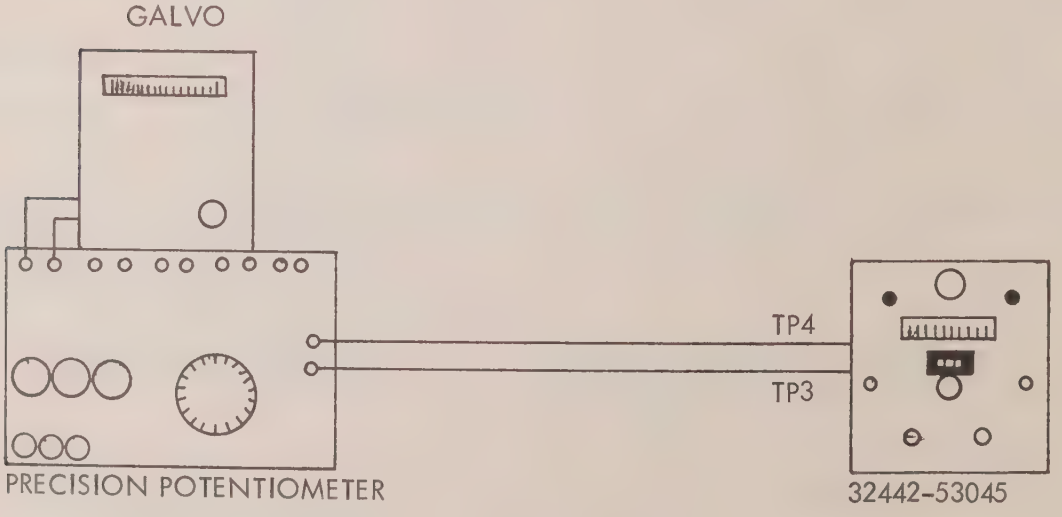


Diagram A

2. Using the Precision Laboratory Potentiometer and its associated L & N galvanometer and regular copper test leads, perform the following adjustment:

   a. Set the Laboratory Potentiometer to 1.0193 volts and adjust resistor R60 for a null indication on the L & N galvanometer. To compensate for the coarseness

of adjustment, depress the number 2 Galvo button for this adjustment. Disconnect the equipment.

3. Reconnect equipment as shown in Diagram B.

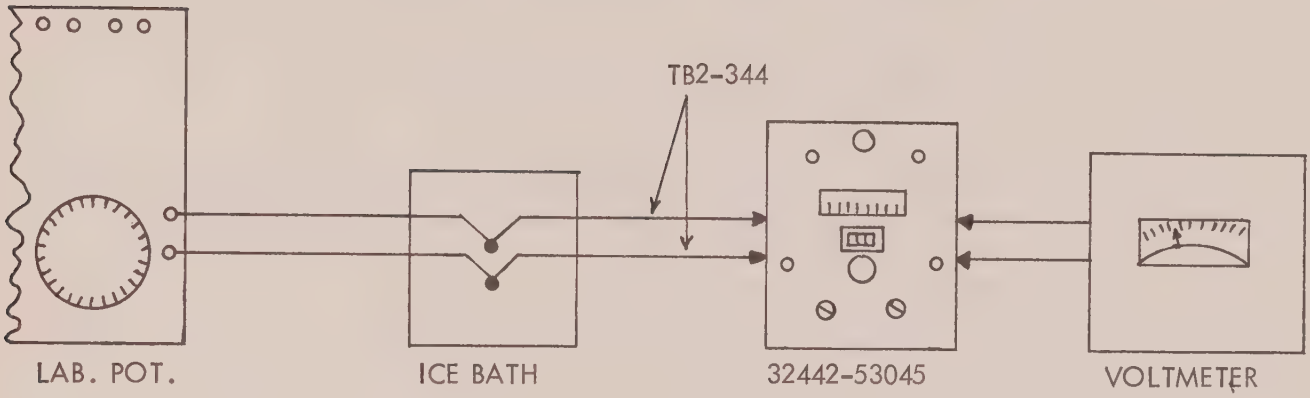


Diagram B

4. Set the Precision Potentiometer at 10°C.

5. Set the controller setpoint to 10°C.

6. Adjust the controller zero adjust (R63) for a voltmeter indication of 0 ±.05 VDC as indicated by one minor division on the Simpson 2.5V scale.

7. Adjust potentiometer R6 to balance the controller deviation meter at null. If the meter will not balance, increase the TP-1 voltage slightly until meter balance is achieved.

8. Set the Precision Potentiometer output to 290°C.

9. Set the controller dial to this temperature.

10. Adjust span potentiometer R101 to balance the controller deviation meter at null. If this adjustment does not produce a null condition, change the setting of potentiometer R60 slightly and repeat steps 4 thru 10.

11. Set the Precision Potentiometer to equal the midpoint scale reading of the controller.

12. Adjust the controller setpoint scale until the controller deviation meter is balanced at null.

13. Read the difference between the Precision Potentiometer and controller scale indications. If greater than 1/2% of full controller span (1.5°C) repeat all previous steps to minimize the error and distribute it evenly over the entire scale. For highest accuracy the error of the Precision Potentiometer at scale points used and the error of the thermocouple wire should be taken into consideration.

6-2 Meter Span Calibration

1. Set the controller setpoint at midscale.

2. Balance the controller deviation meter by adjusting the Precision Potentiometer.

3. Set the Precision Potentiometer 25°C upscale.

4. Adjust potentiometer R21 to balance the controller deviation meter at 25°C.

5. Repeat step 2 and shift the Precision Potentiometer 25°C downscale. Repeat step 4.

6. Adjust the Precision Potentiometer 25°C upscale and downscale. At each point the deviation meter error should be less than + one meter increment. If the error is greater than this, repeat steps 3 thru 5 to minimize the error.

6-3 Proportional Gain Operation Test

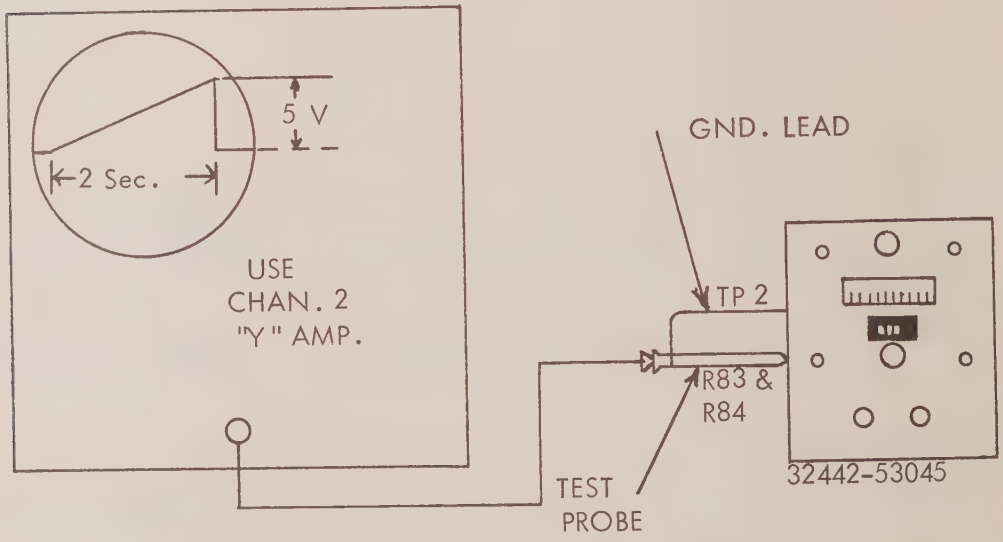


Diagram C

1. Connect the oscilloscope from the junction of resistors R83 and R84 (located in the emitter circuit of Q18 on printed circuit board, PC-1) to TP -2 on printed circuit board, PC-2. Set vertical sensitivity of the oscilloscope to 1V/DIV. Set horizontal sensitivity to .5 Sec/Div.

   NOTE: A ramp type waveform should be evident. Adjust potentiometer R75 on PC-1 for a ramp value of 4.2 volts amplitude, two seconds in duration (see diagram C).

2. Set the proportional gain control to a full counterclockwise (ccw) position. Release "Auto Reset" switch (out position).

3. Set the scale of the controller at midpoint of span.

4. Apply a millivolt input that will balance the deviation meter at null.

5. Output as judged by eye watching the front panel, power indicator lamp should be approximately 50% on-off time.

   NOTE: The following adjustments are to be performed slowly to allow for instrument response time.

6. Adjust MV input until output indication diminishes to zero. Record the temperature equivalent of the MV input.

7. Adjust MV input until output increases to 100%. Record this MV input.

8. The difference between the readings recorded in steps 6 and 7 should be equal to the MV span of the instrument under test, (± 10%).

9. Set the prop gain control fully clockwise (cw). Repeat steps 2,3 and 5.

10. Adjust the MV input until the output diminishes to zero. Record the temperature equivalent of the MV input.

11. Adjust the MV input until the output is increased to 100%. Record this MV input.

12. The difference between the recorded MV input in steps 10 and 11 shall be 1% or less of full scale temperature span of the instrument under test. (algerbraic difference).

    NOTE: In the maximum gain position, the proportional band need not be centered about setpoint; this discrepancy is corrected when the "AUTO RESET" is operative. If the proper proportional gain is not evident, readjust R75 until the desired bandwidth is obtained.

6-4 Automatic Reset Operation Test

1. Repeat steps 2,3 and 4 under the Proportional Gain Test, paragraph 6-3. Set the "RESET" control to maximum clockwise (cw) position.

2. Connect a Simpson voltmeter from TP-2 to TP-6 and another Simpson voltmeter from TP-4 to TP-6. (TP-2, TP-4 and TP-6 are located on PC-4).

3. Change the Setpoint dial to effect a 2 volt change at TP-2.

4. Simultaneously depress "AUTO RESET" switch and start the stopwatch.

5. Record the time required for TP-4 voltage to change 1 volt. This time should be 7.5 $\pm$ 2 seconds.

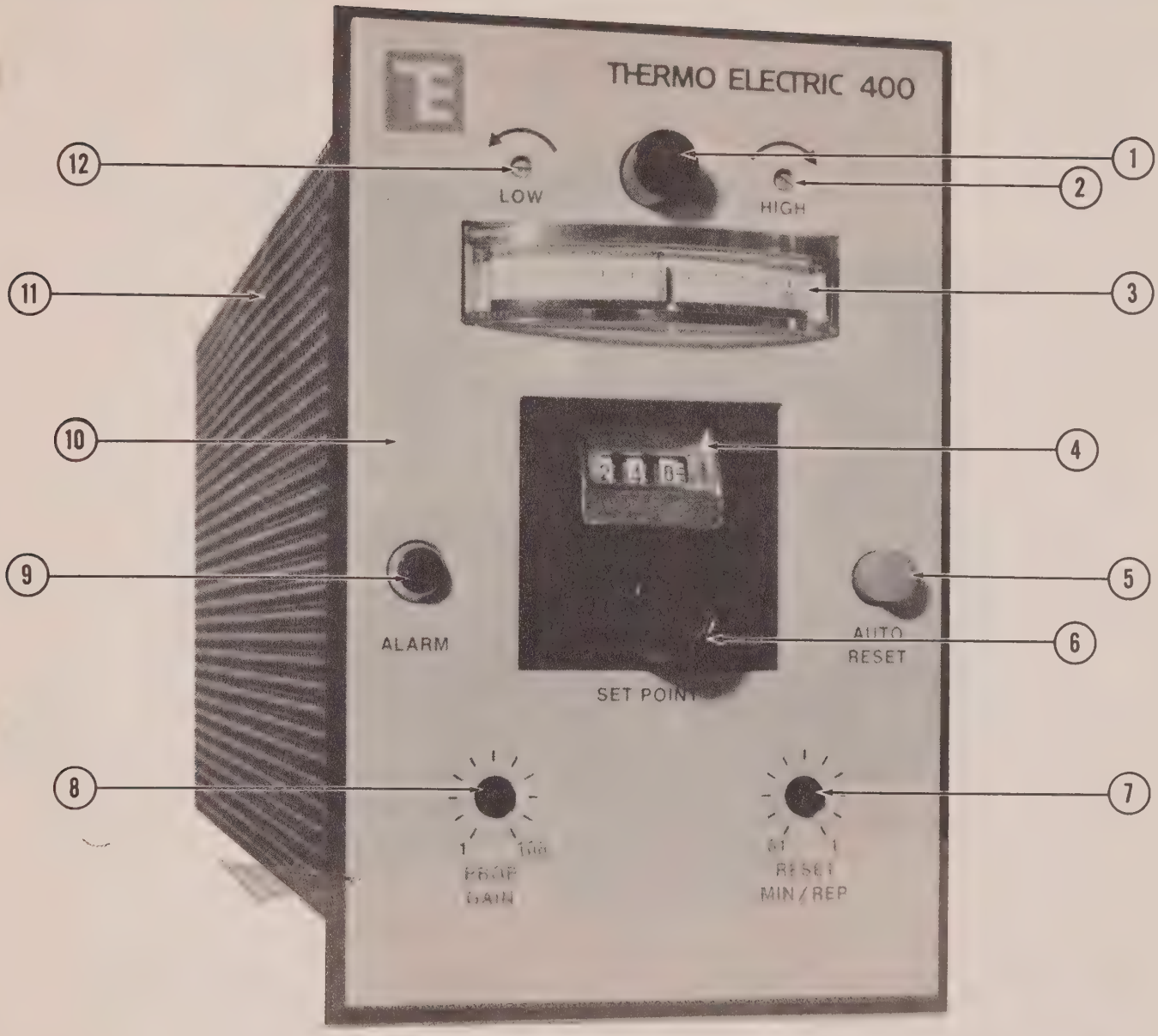
6. Release the "AUTO RESET" switch before proceeding to next step.

7. Set "RESET" control to maximum counterclockwise (ccw) position.

8. Repeat steps 1 and 2 under the Proportional Gain Test, paragraph 6-3, and steps 3 and 4 in this paragraph.

9. Record the time required for the TP-4 voltage to change to maximum voltage or 8 volts, whichever occurs first. This time should be .9 seconds $\pm$ 0.24 seconds.

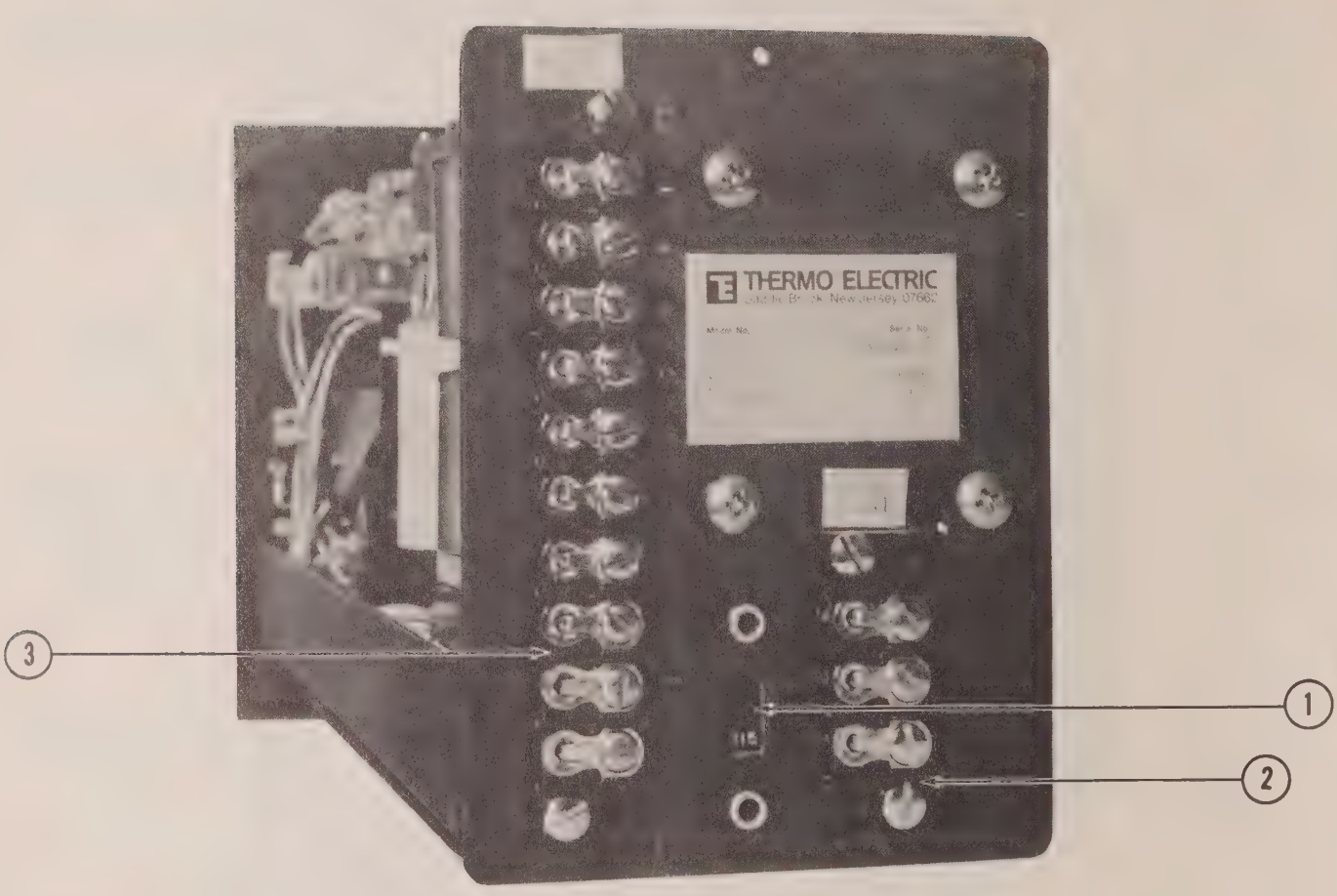
7-0 APPENDIX



Model 32442-53045

1. Indicator lamp ass'y (A4870; G.E. NE-2, neon bulb A5018)
2. High Alarm adjustment (A5554)
3. Indicating deviation meter (A4869-2)
4. Digital turns counting dial (A4974)
5. Auto Reset switch (A5372)
6. Setpoint knob (A5847)
7. Automatic Reset control, 3 megohm potentiometer (A5783-7)
8. Proportional Gain control, 500K ohm potentiometer (A5783-6)
9. Alarm light (A5446)
10. Front Panel (A6021-12)
11. Ventilated (perforated) case (A4788)
12. Low Alarm adjustment (A5554)

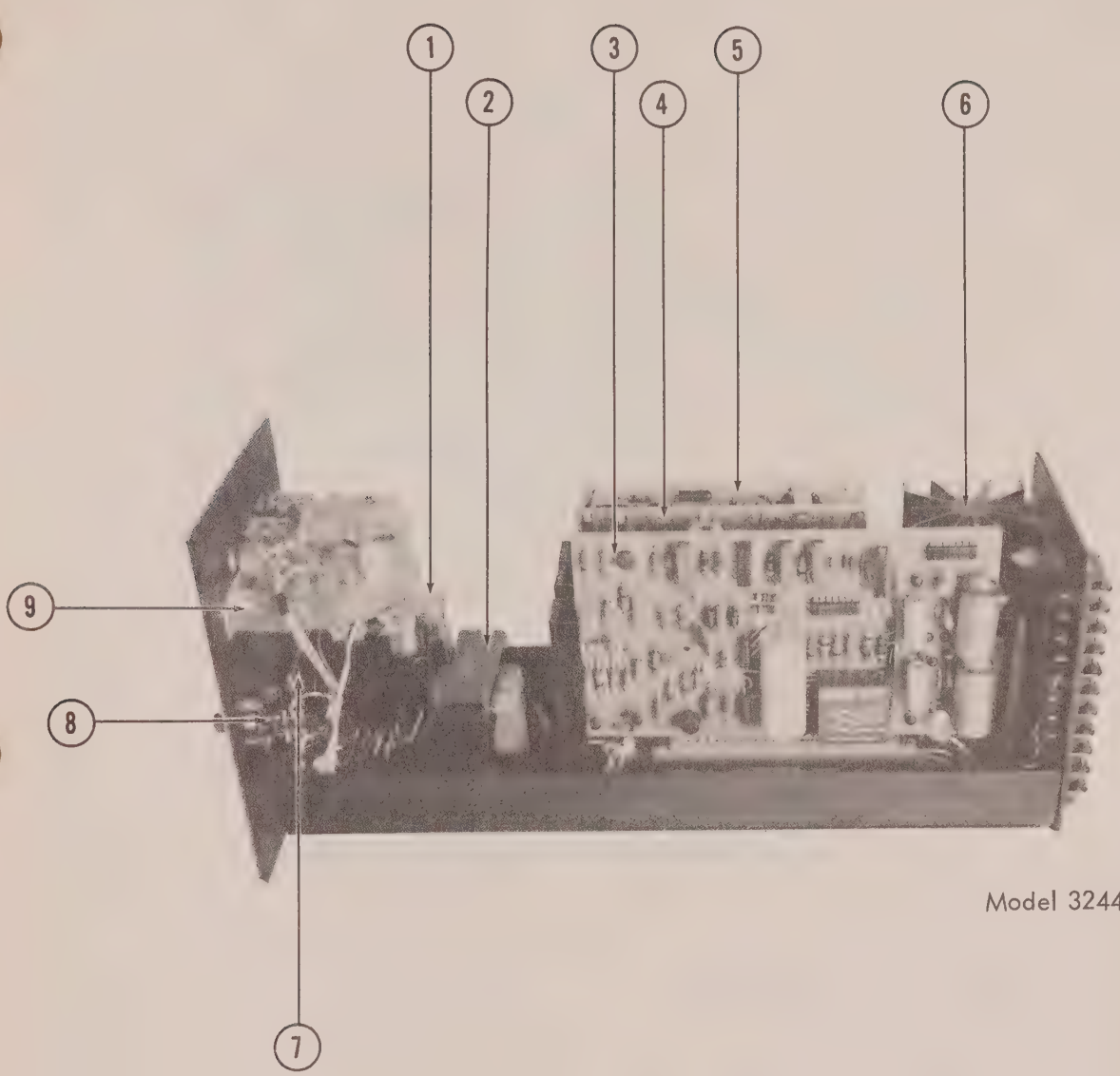
Thermo Electric part numbers appear in parentheses



Model 32442-53045

1. Input voltage selector switch (A4976)
2. Terminal strip (A2787-3)
3. Terminal strip (A2787-10)

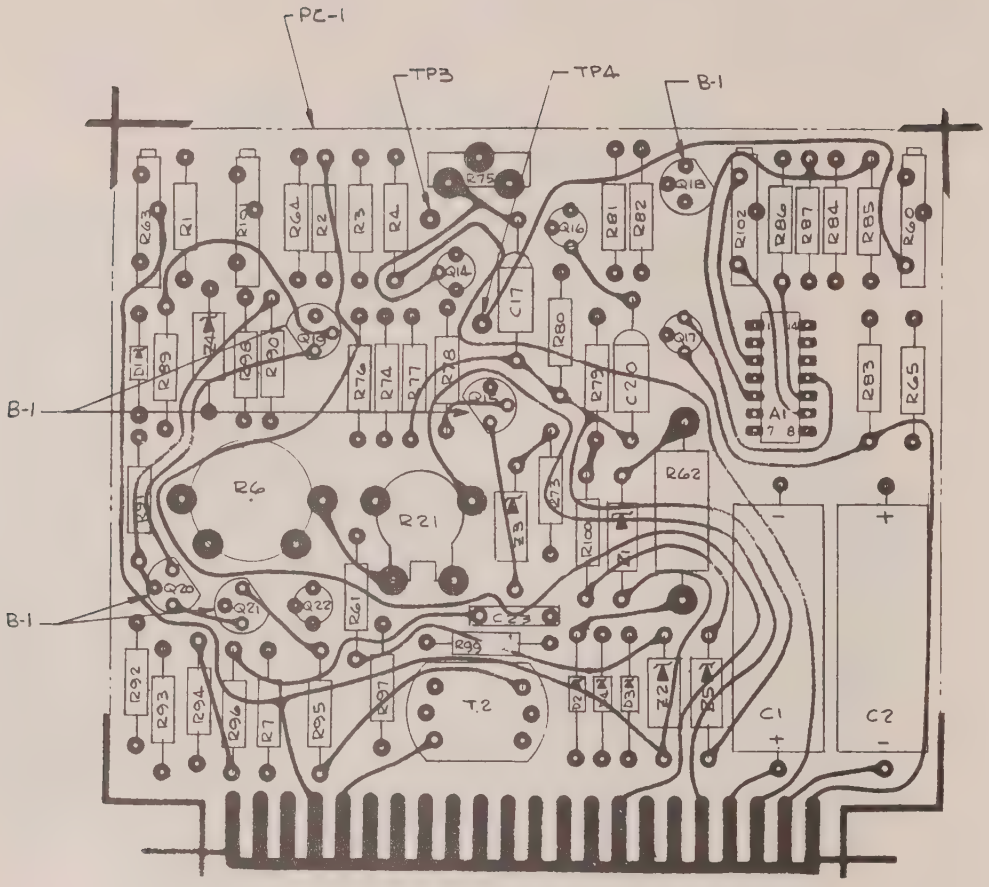
Thermo Electric part numbers appear in parentheses.



Model 32442-53045

1. Relay (A1477)
2. Power transformer (A5781)
3. Power Supply P.C. board assembly (A6316)
4. Amplifier P.C. board assembly (A5782)
5. Op. Amp/Power Supply P.C. board assembly (A6330)
6. Semiconductor cooler (A5364)
7. Digital counting dial (A4974)
8. Auto Reset switch (A5372)
9. Meter (A4869-2)

Thermo Electric part numbers appear in parentheses.



PC-1	Printed circuit board (A6315)
A1	Amplifier, type 741C (A6244)
D1 thru D4	Diode IN4003 (A4473)
Z1	Zener diode ZA18A (A5044)
Z2	Zener diode IN821 (A4736)
Z3	Zener diode ZA18A (A5044)
Z4	Zener diode ZA13A (A5469)
Z5	Zener diode ZA12A (A5237)
Q14	Transistor, unijunction 2N2646 (A4256)
Q15	Transistor 2N3568 (A4729)
Q16	Transistor 2N4249 (A4990)
Q17	Transistor 2N4250 (A5453)
Q18	Transistor 2N3568 (A4729)
Q19	Transistor 2N3566 (A4066)
Q20	Transistor 2N3566 (A4066)
Q21	Transistor 2N3568 (A4729)
Q22	Transistor, unijunction 2N2647 (A5468)
B1	Insulator (A4453)
T2	Transformer, pulse 11Z400 (A5586)

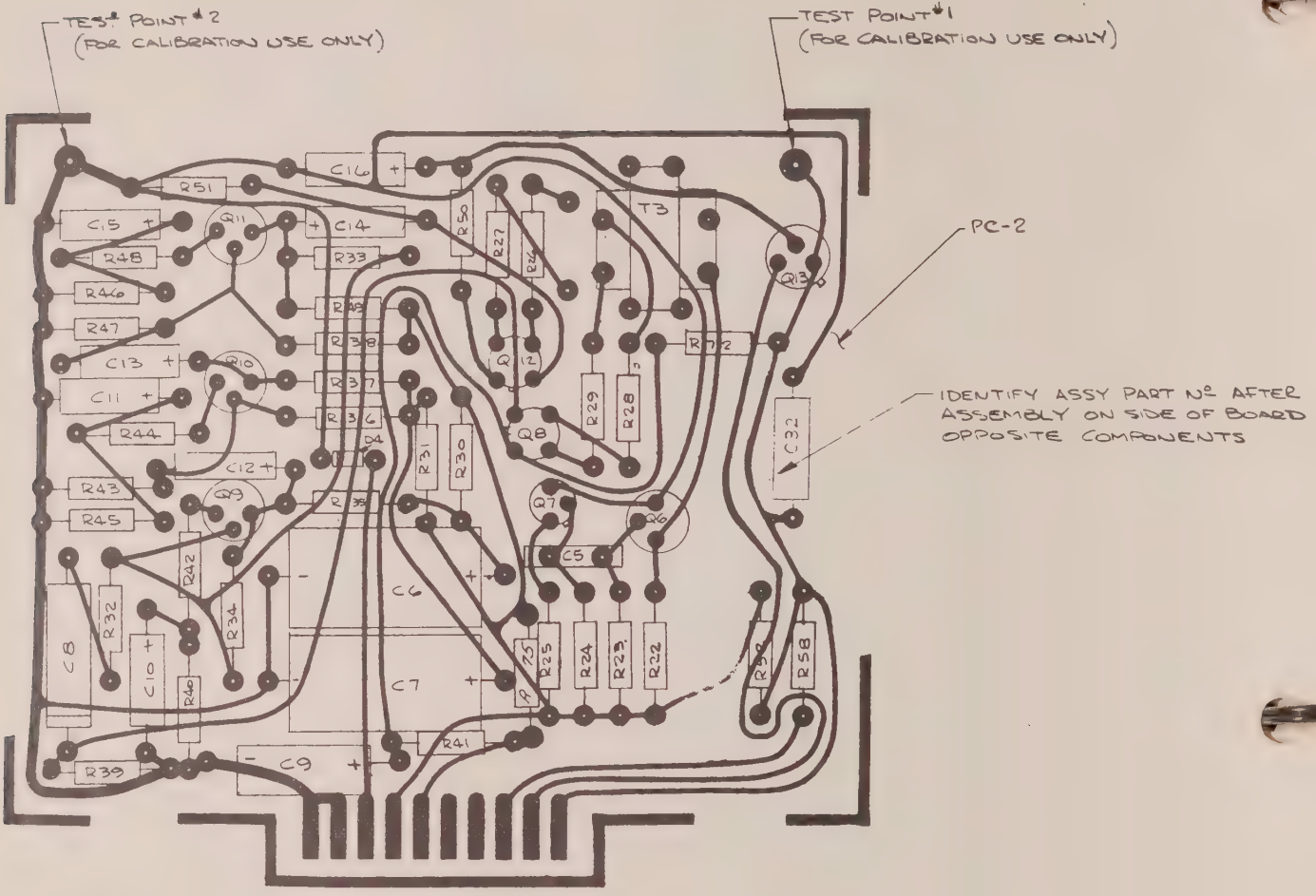
C1	Capacitor 100 mfd. (A3851)
C2	Capacitor 100 mfd. (A3851)
C17	Capacitor 22 mfd. (A5940)
C20	Capacitor 22 mfd. (A5940)
C23	Capacitor 0.1 mfd. (A4263)
R1	Resistor 10 ohms ± 1% (A6314-1)
R2	Resistor 20.5 ohms ± 0.5% (A6314-3)
R3	Resistor 989.25 ohms ± 0.1% (A6314-4)
R4	Resistor 1004.3 ohms ± 0.1% (A6314-5)
R6	Potentiometer 200 ohms (A4264-4)
R7	Resistor 5.1 K ohms (7241-58)
R21	Potentiometer 10 K ohms (A4740)
R60	Potentiometer 1 K ohm (A5241-1)
R61	Resistor 1 K ohm (7241-22)
R62	Resistor 1.5 K ohms, 2 watts (7243-6)
R63	Potentiometer 10 ohms (A6317-1)
R64	Resistor 300 ohms ± 1% (A6314-2)
R65	Resistor 2370 ohms, ohmite 1% (A3849-85)
R73	Resistor 2.7 K ohms (7241-42)
R74	Resistor 47 K ohms (7241-12)
R75	Potentiometer 180 K ohms (A5442-5)
R76	Resistor 100 ohms (7241-101)
R77	Resistor 200 ohms (7241-32)
R78	Resistor 1 K ohm (7241-22)
R79	Resistor 10 K ohms ± 5% (7241-108)
R80	Resistor 10 K ohms ± 5% (7241-108)

R81	Resistor 130 K ohms (7241-121)
R82	Resistor 47 K ohms (7241-12)
R83	Resistor 10 K ohms (7241-13)
R84	Resistor 10 K ohms ± 5% (7241-108)
R85	Resistor 7.5 K ohms ± 5% (7241-59)
R86	Resistor 10 Megohms ± 5% (7241-116)
R87	Resistor 10 Megohms ± 5% (7241-116)
R89	Resistor 6.8 K ohms (7241-17)
R90	Resistor 20 K ohms (7241-118)
R91	Resistor 62 K ohms (7241-119)
R92	Resistor 620 K ohms (7241-89)
R93	Resistor 18 K ohms (7241-39)
R94	Resistor 2.7 K ohms (7241-42)
R95	Resistor 270 ohms (7241-44)
R96	Resistor 1.2 K ohms (7241-62)
R97	Resistor 100 ohms (7241-101)
R98	Resistor 1 K ohm (7241-22)
R99	Resistor 22 ohms (7241-87)
R100	Resistor 390 ohms (7241-80)
R101	Potentiometer 200 ohms (A6317-2)
R102	Potentiometer 10 K ohms (A6245-3)

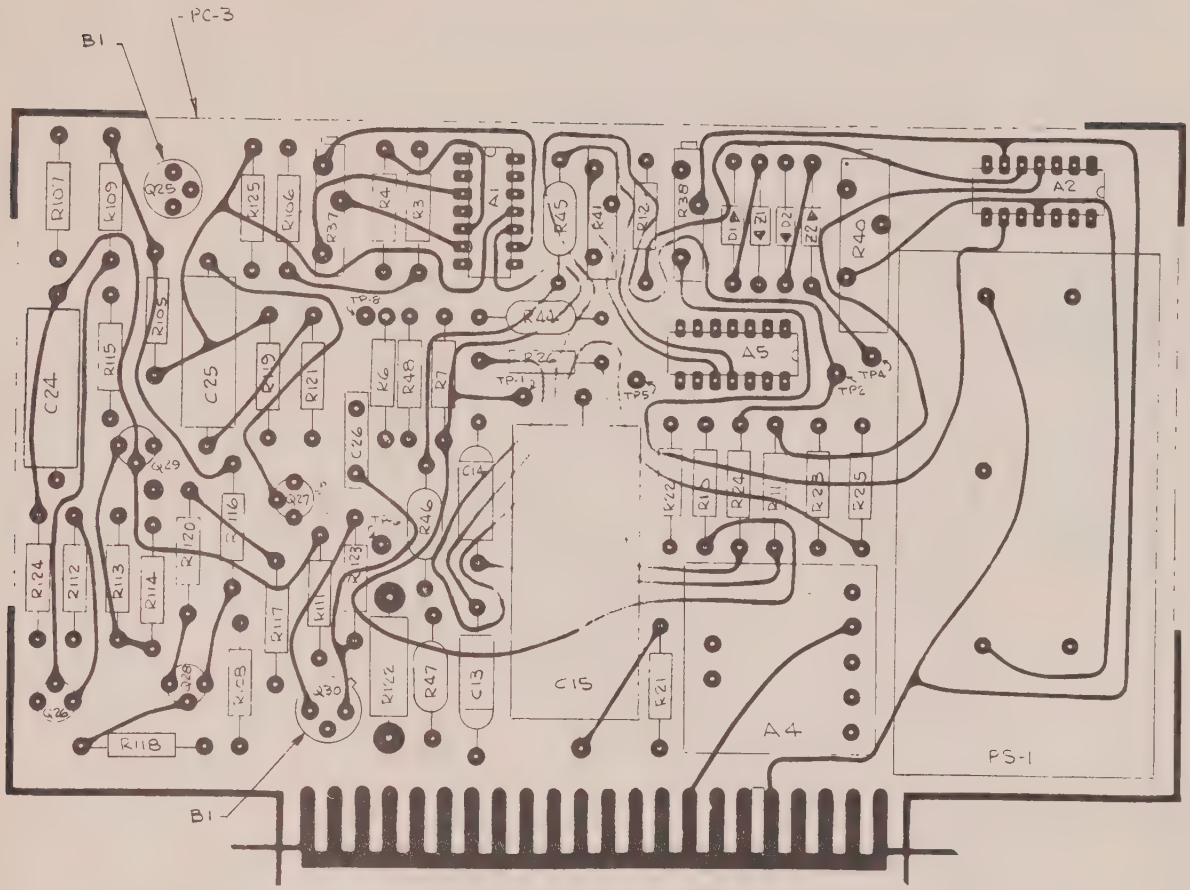
All resistors 1/2 watt, ± 10% unless otherwise specified.
Thermo Electric part numbers appear in parentheses.

R22	Resistor 1.2 K ohms (7241-62)
R23	Resistor 33 K ohms (7241-31)
R24	Resistor 12 K ohms (7241-54)
R25	Resistor 470 ohms (7241-70)
R26 thru R29	Resistor 1.8 K ohms ±5% (7241-88)
R30	Resistor 4.7 K ohms (7241-24)
R31	Resistor 1 K ohm (7241-22)
R32	Resistor 1 K ohm (7241-22)
R33	Resistor 3.3 megohms (7241-55)
R34	Resistor 33 K ohms (7241-31)
R35	Resistor 10 K ohms (7241-13)
R36	Resistor 12 K ohms (7241-54)
R37	Resistor 1.5 K ohms (7241-25)
R38	Resistor 4.7 K ohms (7241-24)
R39	Resistor 2.2 K ohms (7241-21)
R40	Resistor 2.2 K ohms (7241-21)
R41	Resistor 1 K ohm (7241-22)
R42	Resistor 22 ohms (7241-87)
R43	Resistor 4.7 K ohms (7241-24)
R44	Resistor 15 ohms (7241-47)
R45	Resistor 680 ohms (7241-75)
R46	Resistor 330 ohms (7241-14)
R47	Resistor 1.5 K ohms (7241-25)
R48	Resistor 15 ohms (7241-47)
R49	Resistor 820 ohms (7241-81)
R50	Resistor 430 ohms (7241-71)
R51	Resistor 1 K ohms (7241-22)
R52	Resistor 10 K ohms (7241-13)
R53	Resistor 4.7 K ohms (7241-24)
R58	Resistor 7.5 K ohms (7241-59)
R72	Resistor 10 megohms (7241-1)
R75	Resistor 18 megohms (7241-50)
D4	Diode 1N4001 (A5005)

All resistors 1/2 watt, ±10% unless otherwise specified.
Thermo Electric part numbers appear in parentheses.



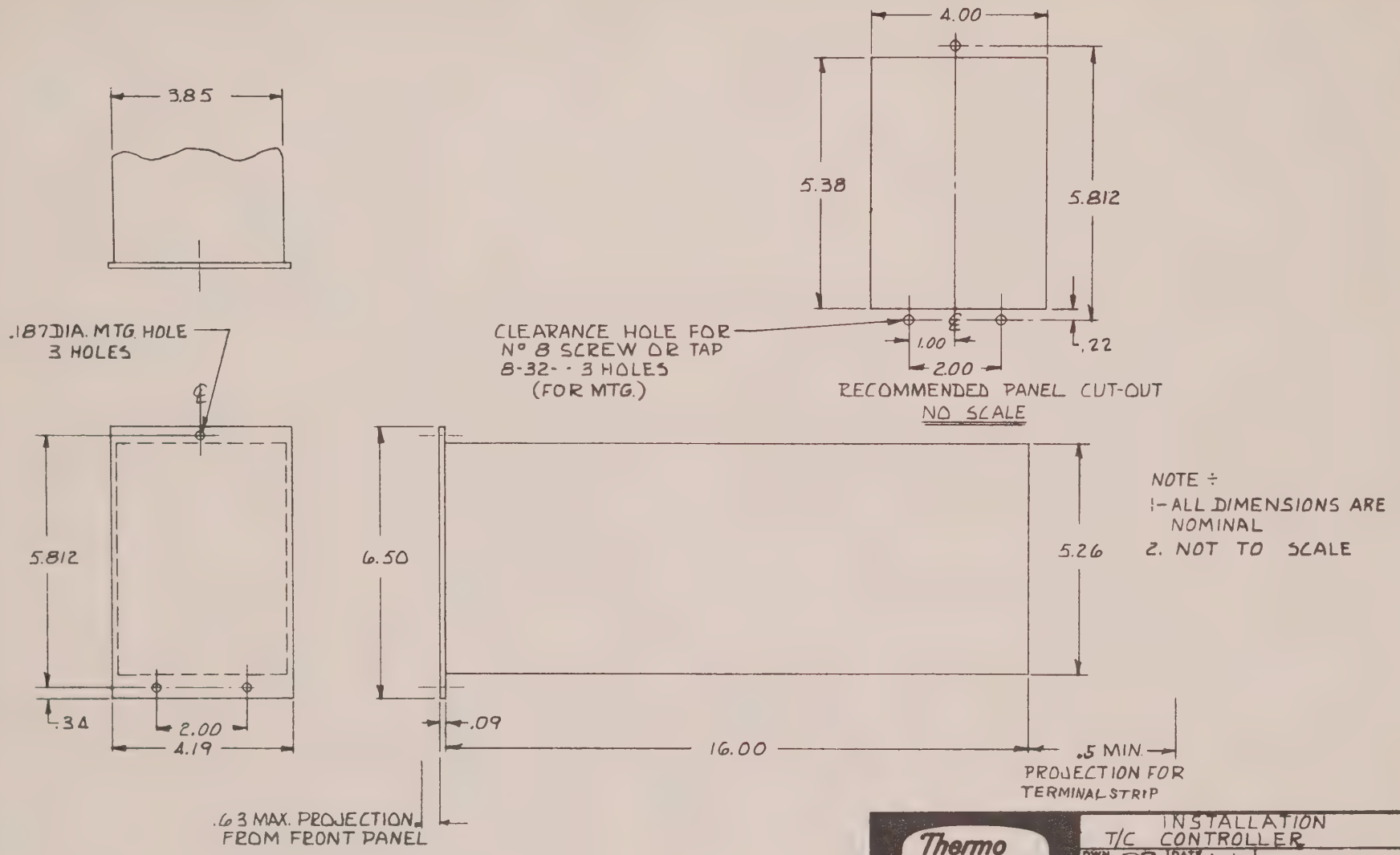
PC-2	Printed circuit board (A5859)
Q6	Transistor 2N3568 (A4729)
Q7	Transistor 5E35 (A4730)
Q8	Transistor 3N88 (A4731)
Q9	Transistor 2N3566 (A4066)
Q10	Transistor 2N3566 (A4066)
Q11	Transistor 2N3566 (A4066)
Q12	Transistor 3N88 (A4731)
Q13	Transistor 2N4250 (A5453)
T3	Transformer UTC-50-16 (A4742)
	Bracket for above (A4745)
C5	Capacitor .01 mfd, 25VDC (7902)
C6	Capacitor 100 mfd, 25 VDC (A4737)
C7	Capacitor 100 mfd, 25 VDC (A4737)
C8	Capacitor .1 mfd, 150 VDC (A4443)
C9	Capacitor 100 mfd, 10 VDC (A5234)
C10 thru C16	Capacitor 15 mfd, 20 VDC (A5235)
C32	Capacitor 15 mfd, 20 VDC (A5235)



PC-3	Printed circuit board (A6329)
A1	Amplifier, type U741C (A6244)
A2	Amplifier, type U741C (A6244)
A4	Amplifier, type D5 (A5758)
A5	Amplifier, type U741C (A6244)
Z1	Zener diode, 7.5V, ZA7.5B (A5936)
Z2	Zener diode, 7.5V, ZA7.5B (A5936)
D1	Diode IN4003 (A4473)
D2	Diode IN4003 (A4473)
Q25	Transistor 2N3566 (A4066)
Q26	Transistor 2N4249 (A4990)
Q27	Transistor, unijunction 2N2646 (A4256)
Q28	Transistor 2N4249 (A4990)
Q29	Transistor, unijunction 2N2646 (A4256)
Q30	Silicon controlled rectifier C-68 (A4447)
B1	Insulator (A4453)
C13	Capacitor 10 mfd., 20 WVDC (A5583)
C14	Capacitor 10 mfd., 20 WVDC (A5583)
C15	Capacitor 5 uF. (A6313)
C24	Capacitor 0.1 uF., 150 WVDC (A4443)
C25	Capacitor 0.1 uF., 150 WVDC (A4443)
C26	Capacitor .01 uF., 600 WVDC (7902)

PS-1	Power supply 100 mA., +15 VDC (A6297)
R3	Resistor 10 K ohms ± 1% (A5938-1)
R4	Resistor 10 K ohms ± 1% (A5938-1)
R6	Resistor 27 K ohms ± 1% (A5838-13)
R7	Resistor 27 K ohms ± 1% (A5938-13)
R10	Resistor 10 K ohms ± 5% (7241-108)
R11	Resistor 4.7 K ohms ± 5% (7241-83)
R12	Resistor 10 K ohms ± 5 % (7241-108)
R21	Resistor 33 K ohms ± 5% (7241-31)
R22	Resistor 10 K ohms (7241-13)
R23	Resistor 10 K ohms ± 2% (A5938-4)
R24	Resistor 10 K ohms ± 5% (7241-108)
R25	Resistor 10 K ohms ± 2% (A5938-4)
R26	Resistor 10 K ohms ± 5% (7241-108)
R37	Potentiometer 10 K ohms ± 5% (A6245-3)
R38	Potentiometer 10 K ohms ± 5% (A6245-3)
R40	Potentiometer 50 K ohms (A6245-5)
R41	Potentiometer 10 K ohms (A6245-3)
R44	Resistor 5 K ohms ± 2 % (A5938-3)
R45	Resistor 10 K ohms ± 2% (A5938-4)
R46	Resistor 5 K ohms ± 2% (A5938-3)
R47	Resistor 5 K ohms ± 2% (A5938-3)
R48	Resistor 36 ± 5% (7241-113)
R105	Resistor 1 K ohm (7241-22)
R106	Resistor 18 K ohms (7241-39)
R107	Resistor 300 ohms ± 5% (7241-67)
R108	Resistor 3.3 K ohms (7241-41)
R109	Resistor 18 K ohms (7241-39)
R111	Resistor 1 Megohm (7241-6)
R112	Resistor 1 K ohm (7241-22)
R113	Resistor 470 ohms (7241-27)
R114	Resistor 3.3 K ohms (7241-41)
R115	Resistor 3.3 K ohms (7241-41)
R116	Resistor 1 K ohm (7241-22)
R117	Resistor 1 Megohm (7241-6)
R118	Resistor 10 K ohms (7241-13)
R119	Resistor 470 ohms (7241-27)
R120	Resistor 3.3 K ohms (7241-41)
R121	Resistor 47 ohms (7241-48)
R122	Resistor 3.3 K ohms ± 1% (7242-14)
R123	Resistor 470 ohms (7241-27)
R124	Resistor 3.3 K ohms (7241-41)
R125	Resistor 270 K ohms (7241-40)

All resistors 1/2 watt, ± 10% unless otherwise specified.
Thermo Electric part numbers appear in parentheses.


3.85
4.00
5.38
5.812
.187 DIA. MTG. HOLE
3 HOLES
CLEARANCE HOLE FOR
Nº 8 SCREW OR TAP
8-32 - 3 HOLES
(FOR MTG.)
1.00
2.00
.22
RECOMMENDED PANEL CUT-OUT
NO SCALE
5.812
.34
2.00
4.19
6.50
5.26
.09
16.00
.5 MIN.
PROJECTION FOR
TERMINAL STRIP
.63 MAX. PROJECTION
FROM FRONT PANEL
NOTE :
1- ALL DIMENSIONS ARE
NOMINAL
2. NOT TO SCALE
Thermo Electric
INSTALLATION
T/C CONTROLLER
DWN. DS
DATE 1/31/91
CKR.
ENGR.
CHK. DR.
PROJ. ENGR.
ID 32442-53045

5.0

I = E/R

P =

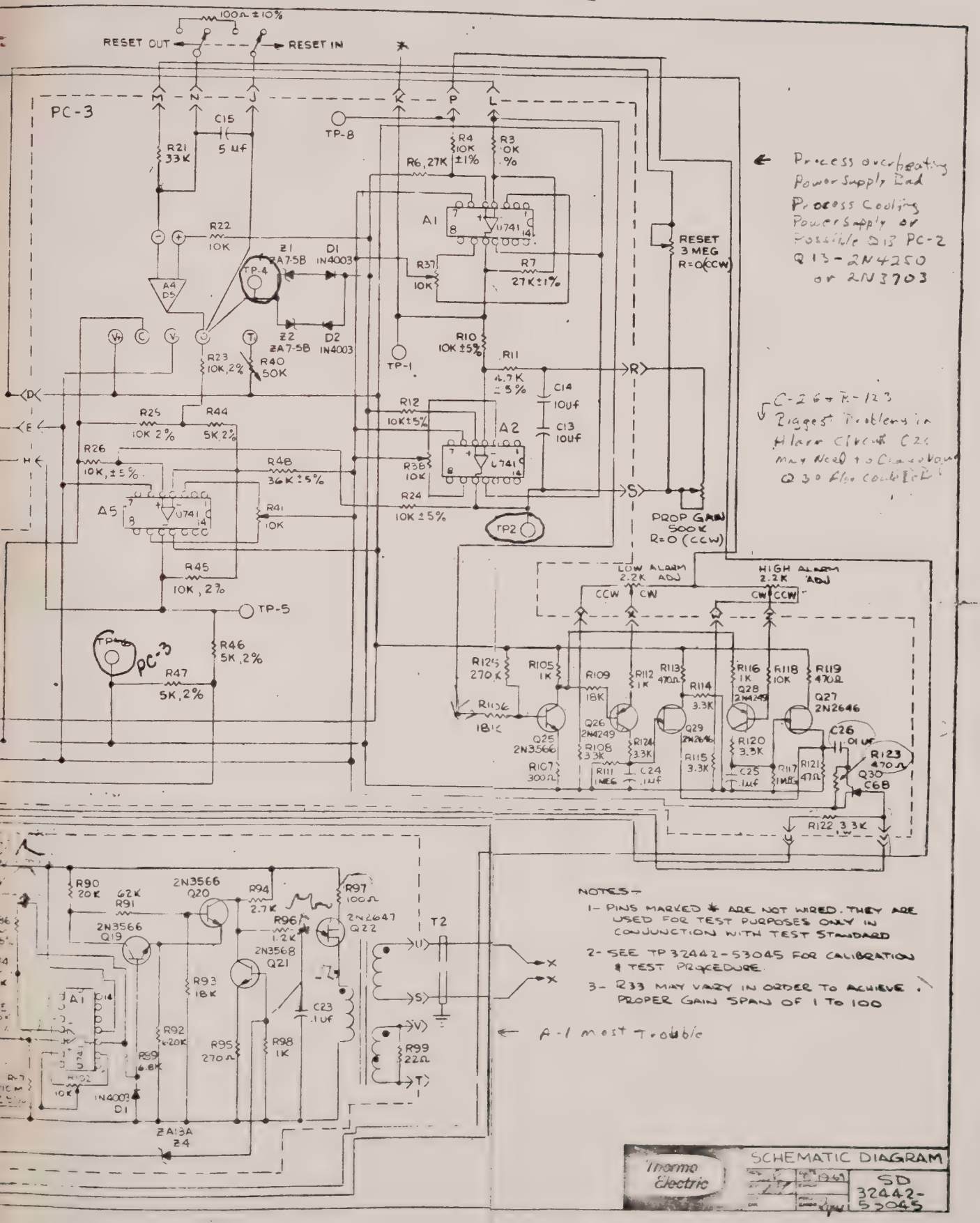
55
1.8
440
55
99.0

1.8
30 | 55.
30
250
240
10

P =
1.8
55
90
90
99.0

TP1-2

A B C D E F H J K L M N P R S T U V W X Y Z



← Process overheating Power Supply Bad
Process Cooling Power Supply or Possible Q13 PC-2
Q13 - 2N4250 or 2N3703

↓ C-26 + R-123 Biggest Problems in Alarm Circuit C26 may Need to Change Value Q30 Also could be

← A-1 most Trouble

NOTES -

1- PINS MARKED * ARE NOT WIRED. THEY ARE USED FOR TEST PURPOSES ONLY IN CONJUNCTION WITH TEST STANDARD

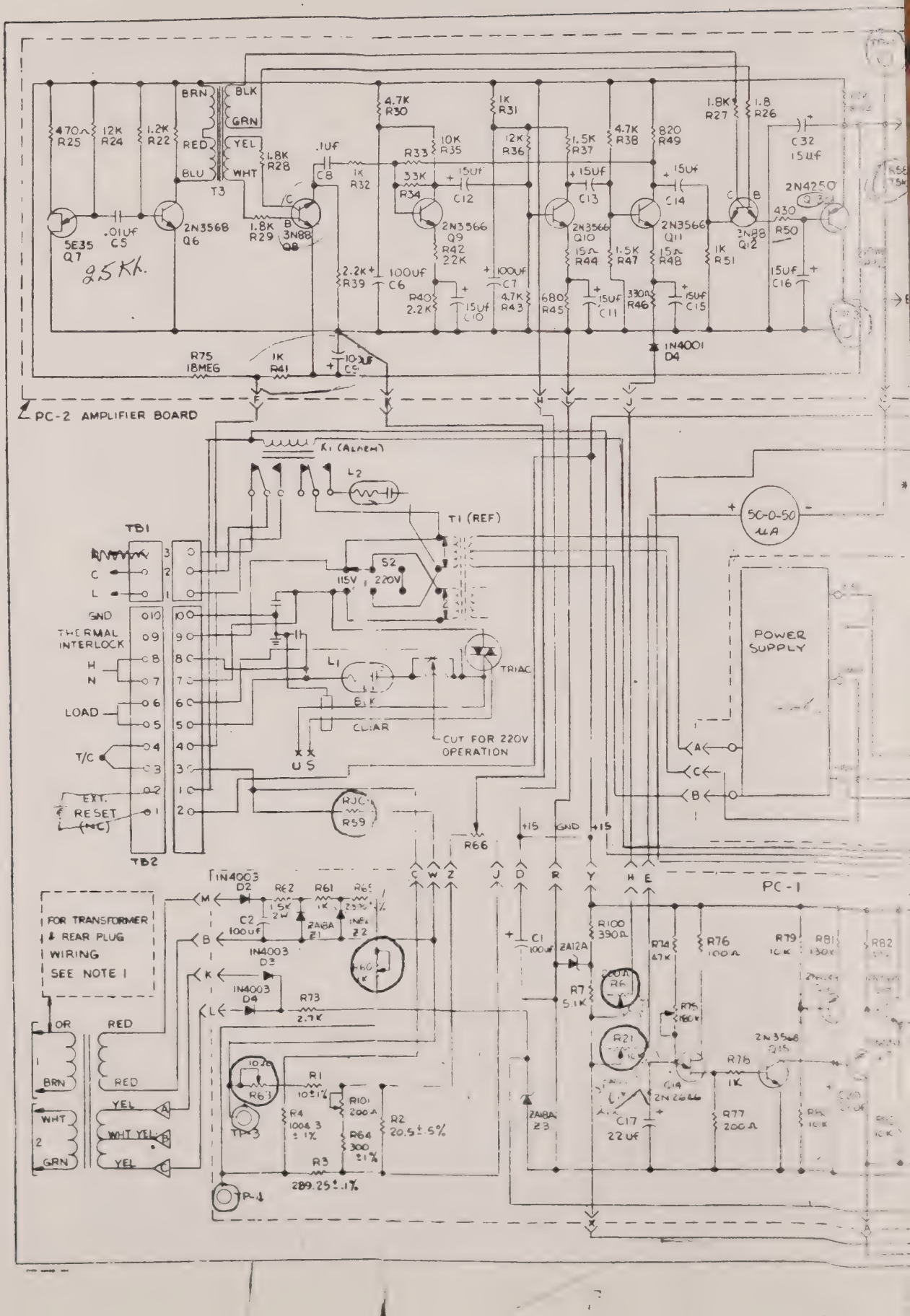
2- SEE TP 32442-53045 FOR CALIBRATION & TEST PROCEDURE.

3- R33 MAY VARY IN ORDER TO ACHIEVE PROPER GAIN SPAN OF 1 TO 100

Thermo Electric

SCHEMATIC DIAGRAM

SD 32442-53045


PC-2 AMPLIFIER BOARD
T3
BRN
BLK
GRN
YEL
RED
WHT
BLU
470Ω R25
12K R24
1.2K R22
.01uf C5
5E35 Q7
2N3568 Q6
25Kh.
1.8K R28
1.8K R29
3N88 Q8
.1uf C8
1K R32
4.7K R30
10K R35
33K R34
15uf C12
2N3566 Q9
R42 22K
2.2K R39
100uf C6
R40 2.2K
15uf C10
1K R31
12K R36
100uf C7
4.7K R43
1.5K R37
4.7K R38
820 R49
15uf C13
2N3566 Q10
15Ω R44
1.5K R47
680 R45
15uf C11
330Ω R46
15uf C14
2N3566 Q11
15Ω R48
15uf C15
1.8K R27
1.8 R26
C32 15uf
2N4250 Q3
2N3568 Q12
430 R50
1K R51
15uf C16
1N4001 D4
R75 18MEG
1K R41
10uf C9
K1 (ALARM)
L2
T1 (REF)
S2
115V
220V
TBI
TB2
GND
THERMAL INTERLOCK
H
N
LOAD
T/C
EXT. RESET (NC)
L1
TRIAC
B.1K
CLEAR
CUT FOR 220V OPERATION
XX
US
RJC
R59
R66
50-0-50 uA
POWER SUPPLY
A
C
B
+15
GND
-15
C W Z J D R Y H E
PC-1
FOR TRANSFORMER & REAR PLUG WIRING SEE NOTE 1
IN4003 D2
IN4003 D3
IN4003 D4
R62 1.5K 2W
R61 1K
R65 25K
C2 100uf
ZA18A Z1
IN647 Z2
R73 2.7K
R63 10K
TP-3
TP-4
R1 10Ω
R4 100Ω 3 ±1%
R3 289.25Ω ±1%
R101 200Ω
R64 300Ω ±1%
R2 20.5Ω ±5%
C1 100uf
ZA12A
R7 5.1K
R100 390Ω
R14 47K
R76 100Ω
R79 10K
R81 130K
R82
R5 100K
R21 10K
2N3568 Q15
R78 1K
C14
2N2646
C17 22uf
ZA18A Z3
R77 200Ω
R84 10K
C18 .1uf
M
B
K
L
1 BRN
RED
2 WHT
GRN
YEL
WHT YEL
A
B
C

IPTS 48

CHROMEL vs. ALUMEL THERMOCOUPLE

Degrees Celsius — Reference Junction 0° C.

Millivolts

°C	0	1	2	3	4	5	6	7	8	9
0	0.00	0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.32	0.36
10	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76
20	0.80	0.84	0.88	0.92	0.96	1.00	1.04	1.08	1.12	1.16
30	1.20	1.24	1.28	1.32	1.36	1.40	1.44	1.48	1.52	1.57
40	1.61	1.65	1.69	1.73	1.77	1.81	1.85	1.90	1.94	1.98
50	2.02	2.06	2.10	2.14	2.18	2.23	2.27	2.31	2.35	2.39
60	2.43	2.47	2.51	2.56	2.60	2.64	2.68	2.72	2.76	2.80
70	2.85	2.89	2.93	2.97	3.01	3.05	3.10	3.14	3.18	3.22
80	3.26	3.30	3.35	3.39	3.43	3.47	3.51	3.56	3.60	3.64
90	3.68	3.72	3.76	3.81	3.85	3.89	3.93	3.97	4.01	4.05
100	4.10	4.14	4.18	4.22	4.26	4.31	4.35	4.39	4.43	4.47
110	4.51	4.55	4.60	4.64	4.68	4.72	4.76	4.80	4.84	4.88
120	4.92	4.96	5.01	5.05	5.09	5.13	5.17	5.21	5.25	5.29
130	5.33	5.37	5.41	5.45	5.49	5.53	5.57	5.61	5.65	5.69
140	5.73	5.77	5.81	5.85	5.89	5.93	5.97	6.01	6.05	6.09
150	6.13	6.17	6.21	6.25	6.29	6.33	6.37	6.41	6.45	6.49
160	6.53	6.57	6.61	6.65	6.69	6.73	6.77	6.81	6.85	6.89
170	6.93	6.97	7.01	7.05	7.09	7.13	7.17	7.21	7.25	7.29
180	7.33	7.37	7.41	7.45	7.49	7.53	7.57	7.61	7.65	7.69
190	7.73	7.77	7.81	7.85	7.89	7.93	7.97	8.01	8.05	8.09
200	8.13	8.17	8.21	8.25	8.29	8.33	8.37	8.41	8.45	8.50
210	8.54	8.58	8.62	8.66	8.70	8.74	8.78	8.82	8.86	8.90
220	8.94	8.98	9.02	9.06	9.10	9.14	9.18	9.22	9.26	9.30
230	9.34	9.38	9.42	9.46	9.50	9.54	9.58	9.63	9.67	9.71
240	9.75	9.79	9.83	9.87	9.91	9.95	9.99	10.03	10.07	10.11
250	10.15	10.20	10.24	10.28	10.32	10.36	10.40	10.44	10.48	10.52
260	10.57	10.61	10.65	10.69	10.73	10.77	10.81	10.85	10.89	10.93
270	10.98	11.02	11.06	11.10	11.14	11.18	11.22	11.26	11.30	11.34
280	11.39	11.43	11.47	11.51	11.55	11.59	11.63	11.67	11.72	11.76
290	11.80	11.84	11.88	11.92	11.96	12.01	12.05	12.09	12.13	12.17
300	12.21	12.25	12.29	12.34	12.38	12.42	12.46	12.50	12.54	12.58
310	12.63	12.67	12.71	12.75	12.79	12.83	12.87	12.92	12.96	13.00
320	13.04	13.08	13.12	13.17	13.21	13.25	13.29	13.33	13.37	13.42
330	13.46	13.50	13.54	13.58	13.62	13.67	13.71	13.75	13.79	13.83
340	13.88	13.92	13.96	14.00	14.04	14.09	14.13	14.17	14.21	14.25
350	14.29	14.34	14.38	14.42	14.46	14.50	14.55	14.59	14.63	14.67
360	14.71	14.76	14.80	14.84	14.88	14.92	14.97	15.01	15.05	15.09
370	15.13	15.18	15.22	15.26	15.30	15.34	15.39	15.43	15.47	15.51
380	15.55	15.60	15.64	15.68	15.72	15.76	15.81	15.85	15.89	15.93
390	15.98	16.02	16.06	16.10	16.14	16.19	16.23	16.27	16.31	16.36
400	16.40	16.44	16.48	16.52	16.57	16.61	16.65	16.69	16.74	16.78
410	16.82	16.86	16.91	16.95	16.99	17.03	17.07	17.12	17.16	17.20
420	17.24	17.29	17.33	17.37	17.41	17.45	17.50	17.54	17.58	17.62
430	17.67	17.71	17.75	17.79	17.84	17.88	17.92	17.96	18.01	18.05
440	18.09	18.13	18.17	18.22	18.26	18.30	18.34	18.39	18.43	18.47
450	18.51	18.56	18.60	18.64	18.68	18.73	18.77	18.81	18.85	18.90
460	18.94	18.98	19.02	19.07	19.11	19.15	19.19	19.24	19.28	19.32
470	19.36	19.41	19.45	19.49	19.54	19.58	19.62	19.66	19.71	19.75
480	19.79	19.84	19.88	19.92	19.96	20.01	20.05	20.09	20.13	20.18
490	20.22	20.26	20.31	20.35	20.39	20.43	20.48	20.52	20.56	20.60
500	20.65	20.69	20.73	20.77	20.82	20.86	20.90	20.94	20.99	21.03
510	21.07	21.11	21.16	21.20	21.24	21.28	21.32	21.37	21.41	21.45
520	21.50	21.54	21.58	21.63	21.67	21.71	21.75	21.80	21.84	21.88
530	21.92	21.97	22.01	22.05	22.09	22.14	22.18	22.22	22.26	22.31
540	22.35	22.39	22.43	22.48	22.52	22.56	22.61	22.65	22.69	22.73
550	22.78	22.82	22.86	22.90	22.95	22.99	23.03	23.07	23.12	23.16
560	23.20	23.25	23.29	23.33	23.38	23.42	23.46	23.50	23.54	23.59
570	23.63	23.67	23.72	23.76	23.80	23.84	23.89	23.93	23.97	24.01
580	24.06	24.10	24.14	24.18	24.23	24.27	24.31	24.36	24.40	24.44
590	24.49	24.53	24.57	24.61	24.65	24.70	24.74	24.78	24.83	24.87

IPTS 48

CHROMEL vs. ALUMEL THERMOCOUPLE

Degrees Celsius — Reference Junction 0° C.

Millivolts

°C	0	1	2	3	4	5	6	7	8	9
600	24.91	24.95	25.00	25.04	25.08	25.12	25.17	25.21	25.25	25.28
610	25.34	25.38	25.42	25.47	25.51	25.55	25.59	25.64	25.68	25.72
620	25.76	25.81	25.85	25.89	25.93	25.98	26.02	26.06	26.10	26.15
630	26.19	26.23	26.27	26.32	26.36	26.40	26.44	26.48	26.53	26.57
640	26.61	26.65	26.70	26.74	26.78	26.82	26.86	26.91	26.95	26.99
650	27.03	27.07	27.12	27.16	27.20	27.24	27.28	27.33	27.37	27.41
660	27.45	27.49	27.54	27.58	27.62	27.66	27.71	27.75	27.79	27.83
670	27.87	27.92	27.96	28.00	28.04	28.08	28.13	28.17	28.21	28.25
680	28.29	28.34	28.38	28.42	28.46	28.50	28.55	28.59	28.63	28.67
690	28.72	28.76	28.80	28.84	28.88	28.93	28.97	29.01	29.05	29.10
700	29.14	29.18	29.22	29.26	29.30	29.35	29.39	29.43	29.47	29.52
710	29.56	29.60	29.64	29.68	29.72	29.77	29.81	29.85	29.89	29.93
720	29.97	30.02	30.06	30.10	30.14	30.18	30.23	30.27	30.31	30.35
730	30.39	30.44	30.48	30.52	30.56	30.60	30.65	30.69	30.73	30.77
740	30.81	30.86	30.90	30.94	30.98	31.02	31.06	31.10	31.15	31.19
750	31.23	31.27	31.31	31.35	31.40	31.44	31.48	31.52	31.56	31.60
760	31.65	31.69	31.73	31.77	31.81	31.85	31.90	31.94	31.98	32.02
770	32.06	32.10	32.15	32.19	32.23	32.27	32.31	32.35	32.39	32.43
780	32.48	32.52	32.56	32.60	32.64	32.68	32.72	32.76	32.81	32.85
790	32.89	32.93	32.97	33.01	33.05	33.09	33.13	33.18	33.22	33.26
800	33.30	33.34	33.38	33.42	33.46	33.50	33.54	33.58	33.63	33.67
810	33.71	33.75	33.79	33.83	33.87	33.91	33.95	33.99	34.04	34.08
820	34.12	34.16	34.20	34.24	34.28	34.32	34.36	34.40	34.44	34.48
830	34.53	34.57	34.61	34.65	34.69	34.73	34.77	34.81	34.85	34.89
840	34.93	34.97	35.02	35.06	35.10	35.14	35.18	35.22	35.26	35.30
850	35.34	35.38	35.42	35.46	35.50	35.54	35.58	35.63	35.67	35.71
860	35.75	35.79	35.83	35.87	35.91	35.95	35.99	36.03	36.07	36.11
870	36.15	36.19	36.23	36.27	36.31	36.35	36.39	36.43	36.47	36.51
880	36.55	36.59	36.63	36.67	36.72	36.76	36.80	36.84	36.88	36.92
890	36.96	37.00	37.04	37.08	37.12	37.16	37.20	37.24	37.28	37.32
900	37.36	37.40	37.44	37.48	37.52	37.56	37.60	37.64	37.68	37.72
910	37.76	37.80	37.84	37.88	37.92	37.96	38.00	38.04	38.08	38.12
920	38.16	38.20	38.24	38.28	38.32	38.36	38.40	38.44	38.48	38.52
930	38.56	38.60	38.64	38.68	38.72	38.76	38.80	38.84	38.88	38.92
940	38.95	38.99	39.03	39.07	39.11	39.15	39.19	39.23	39.27	39.31
950	39.35	39.39	39.43	39.47	39.51	39.55	39.59	39.63	39.67	39.71
960	39.75	39.79	39.83	39.88	39.90	39.94	39.98	40.02	40.06	40.10
970	40.14	40.18	40.22	40.26	40.30	40.34	40.38	40.41	40.45	40.49
980	40.53	40.57	40.61	40.65	40.69	40.73	40.77	40.81	40.85	40.89
990	40.92	40.96	41.00	41.04	41.08	41.12	41.18	41.20	41.24	41.28
1000	41.31	41.35	41.39	41.43	41.47	41.51	41.55	41.59	41.63	41.67
1010	41.70	41.74	41.78	41.82	41.86	41.90	41.94	41.98	42.02	42.05
1020	42.09	42.13	42.17	42.21	42.25	42.29	42.33	42.36	42.40	42.44
1030	42.48	42.52	42.56	42.60	42.63	42.67	42.71	42.75	42.79	42.83
1040	42.87	42.90	42.94	42.98	43.02	43.06	43.10	43.14	43.17	43.21
1050	43.25	43.29	43.33	43.37	43.41	43.44	43.48	43.52	43.56	43.60
1060	43.63	43.67	43.71	43.75	43.79	43.83	43.87	43.90	43.94	43.98
1070	44.02	44.06	44.10	44.14	44.17	44.21	44.25	44.29	44.33	44.36
1080	44.40	44.44	44.48	44.52	44.55	44.59	44.63	44.67	44.71	44.74
1090	44.78	44.82	44.86	44.90	44.93	44.97	45.01	45.05	45.09	45.12
1100	45.16	45.20	45.24	45.27	45.31	45.35	45.39	45.43	45.46	45.50
1110	45.54	45.58	45.62	45.65	45.69	45.73	45.77	45.80	45.84	45.88
1120	45.92	45.95	45.99	46.03	46.07	46.11	46.14	46.18	46.22	46.26
1130	46.29	46.33	46.37	46.41	46.44	46.48	46.52	46.56	46.59	46.63
1140	46.67	46.70	46.74	46.78	46.82	46.85	46.89	46.93	46.97	47.00
1150	47.04	47.08	47.12	47.15	47.19	47.23	47.26	47.30	47.34	47.38
1160	47.41	47.45	47.49	47.52	47.56	47.60	47.63	47.67	47.71	47.75
1170	47.78	47.82	47.86	47.89	47.93	47.97	48.00	48.04	48.08	48.12
1180	48.15	48.19	48.23	48.26	48.30	48.34	48.37	48.41	48.45	48.48
1190	48.52	48.56	48.59	48.63	48.67	48.70	48.74	48.78	48.81	48.85

IPTS 48

IRON vs. CONSTANTAN THERMOCOUPLE

Degrees Celsius — Reference Junction 0° C.

Millivolts

°C	0	1	2	3	4	5	6	7	8	9
-190	-7.66	-7.69	-7.71	-7.73	-7.75	-7.78				
-180	-7.40	-7.43	-7.46	-7.48	-7.51	-7.54	-7.56	-7.58	-7.61	-7.64
-170	-7.12	-7.15	-7.18	-7.21	-7.24	-7.27	-7.30	-7.32	-7.35	-7.38
-160	-6.82	-6.85	-6.88	-6.91	-6.94	-6.97	-7.00	-7.03	-7.06	-7.09
-150	-6.50	-6.53	-6.56	-6.60	-6.63	-6.66	-6.69	-6.72	-6.76	-6.79
-140	-6.16	-6.19	-6.22	-6.26	-6.29	-6.33	-6.36	-6.40	-6.43	-6.46
-130	-5.80	-5.84	-5.87	-5.91	-5.94	-5.98	-6.01	-6.05	-6.08	-6.12
-120	-5.42	-5.46	-5.50	-5.54	-5.58	-5.61	-5.65	-5.69	-5.72	-5.76
-110	-5.03	-5.07	-5.11	-5.15	-5.19	-5.23	-5.27	-5.31	-5.35	-5.38
-100	-4.63	-4.67	-4.71	-4.75	-4.79	-4.83	-4.87	-4.91	-4.95	-4.99
-90	-4.21	-4.25	-4.30	-4.34	-4.38	-4.42	-4.46	-4.50	-4.55	-4.59
-80	-3.78	-3.82	-3.87	-3.91	-3.96	-4.00	-4.04	-4.08	-4.13	-4.17
-70	-3.34	-3.38	-3.43	-3.47	-3.52	-3.56	-3.60	-3.65	-3.69	-3.74
-60	-2.89	-2.94	-2.98	-3.03	-3.07	-3.12	-3.16	-3.21	-3.25	-3.30
-50	-2.43	-2.48	-2.52	-2.57	-2.62	-2.66	-2.71	-2.75	-2.80	-2.84
-40	-1.96	-2.01	-2.06	-2.10	-2.15	-2.20	-2.24	-2.29	-2.34	-2.38
-30	-1.48	-1.53	-1.58	-1.63	-1.67	-1.72	-1.77	-1.82	-1.87	-1.91
-20	-1.00	-1.04	-1.09	-1.14	-1.19	-1.23	-1.28	-1.34	-1.39	-1.43
-10	-0.50	-0.55	-0.60	-0.65	-0.70	-0.75	-0.80	-0.85	-0.90	-0.95
-0	0.00	-0.05	-0.10	-0.15	-0.20	-0.25	-0.30	-0.35	-0.40	-0.45
+0	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45
10	0.50	0.56	0.61	0.66	0.71	0.76	0.81	0.86	0.92	0.97
20	1.02	1.07	1.12	1.17	1.22	1.28	1.33	1.38	1.43	1.48
30	1.54	1.59	1.64	1.69	1.74	1.80	1.85	1.90	1.95	2.00
40	2.06	2.11	2.16	2.22	2.27	2.32	2.37	2.42	2.48	2.53
50	2.59	2.64	2.69	2.74	2.80	2.85	2.90	2.95	3.01	3.06
60	3.11	3.17	3.22	3.27	3.33	3.38	3.43	3.49	3.54	3.60
70	3.65	3.70	3.76	3.81	3.86	3.92	3.97	4.02	4.08	4.13
80	4.19	4.24	4.29	4.35	4.40	4.46	4.51	4.56	4.62	4.67
90	4.73	4.78	4.83	4.89	4.94	5.00	5.05	5.10	5.16	5.21
100	5.27	5.32	5.38	5.43	5.48	5.54	5.59	5.65	5.70	5.76
110	5.81	5.86	5.92	5.97	6.03	6.08	6.14	6.19	6.25	6.30
120	6.36	6.41	6.47	6.52	6.58	6.63	6.68	6.74	6.79	6.85
130	6.90	6.96	7.01	7.07	7.12	7.18	7.23	7.29	7.34	7.40
140	7.45	7.51	7.56	7.62	7.67	7.73	7.78	7.84	7.89	7.95
150	8.00	8.06	8.12	8.17	8.23	8.28	8.34	8.39	8.45	8.50
160	8.56	8.61	8.67	8.72	8.78	8.84	8.89	8.95	9.00	9.06
170	9.11	9.17	9.22	9.28	9.33	9.39	9.44	9.50	9.56	9.61
180	9.67	9.72	9.78	9.83	9.89	9.95	10.00	10.06	10.11	10.17
190	10.22	10.28	10.34	10.39	10.45	10.50	10.56	10.61	10.67	10.73
200	10.78	10.84	10.89	10.95	11.00	11.06	11.12	11.17	11.23	11.29
210	11.34	11.39	11.45	11.50	11.56	11.62	11.67	11.73	11.78	11.84
220	11.89	11.95	12.00	12.06	12.12	12.17	12.23	12.28	12.34	12.39
230	12.45	12.50	12.56	12.62	12.67	12.73	12.78	12.84	12.89	12.95
240	13.01	13.06	13.12	13.17	13.23	13.28	13.34	13.40	13.45	13.51
250	13.56	13.62	13.67	13.73	13.78	13.84	13.89	13.95	14.00	14.06
260	14.12	14.17	14.23	14.28	14.34	14.39	14.45	14.50	14.56	14.61
270	14.67	14.72	14.78	14.83	14.89	14.94	15.00	15.06	15.11	15.17
280	15.22	15.28	15.33	15.39	15.44	15.50	15.55	15.61	15.66	15.72
290	15.77	15.83	15.88	15.94	16.00	16.05	16.11	16.16	16.22	16.27
300	16.33	16.38	16.44	16.49	16.55	16.60	16.66	16.71	16.77	16.82
310	16.88	16.93	16.99	17.04	17.10	17.15	17.21	17.26	17.32	17.37
320	17.43	17.48	17.54	17.60	17.65	17.71	17.76	17.82	17.87	17.93
330	17.98	18.04	18.09	18.15	18.20	18.26	18.32	18.37	18.43	18.48
340	18.54	18.59	18.65	18.70	18.76	18.81	18.87	18.92	18.98	19.03
350	19.09	19.14	19.20	19.25	19.31	19.37	19.42	19.48	19.53	19.59
360	19.64	19.70	19.75	19.81	19.86	19.92	19.97	20.03	20.08	20.14
370	20.20	20.25	20.31	20.36	20.42	20.47	20.53	20.58	20.64	20.69
380	20.75	20.80	20.86	20.91	20.97	21.02	21.08	21.13	21.19	21.24
390	21.30	21.35	21.41	21.46	21.52	21.57	21.63	21.68	21.74	21.79

IPTS 48

IRON vs. CONSTANTAN THERMOCOUPLE

Degrees Celsius — Reference Junction 0° C.

Millivolts

°C	0	1	2	3	4	5	6	7	8	9
400	21.85	21.90	21.96	22.02	22.07	22.13	22.18	22.24	22.29	22.35
410	22.40	22.46	22.51	22.57	22.62	22.68	22.73	22.79	22.84	22.90
420	22.95	23.01	23.06	23.12	23.17	23.23	23.28	23.34	23.39	23.45
430	23.50	23.56	23.61	23.67	23.72	23.78	23.83	23.89	23.94	24.00
440	24.06	24.11	24.17	24.22	24.28	24.33	24.39	24.44	24.50	24.55
450	24.61	24.66	24.72	24.77	24.83	24.88	24.94	25.00	25.05	25.11
460	25.16	25.22	25.27	25.33	25.38	25.44	25.49	25.55	25.60	25.66
470	25.72	25.77	25.83	25.88	25.94	25.99	26.05	26.10	26.16	26.22
480	26.27	26.33	26.38	26.44	26.49	26.55	26.61	26.66	26.72	26.77
490	26.83	26.88	26.94	27.00	27.05	27.11	27.17	27.22	27.28	27.33
500	27.39	27.45	27.50	27.56	27.61	27.67	27.73	27.78	27.84	27.90
510	27.95	28.01	28.07	28.12	28.18	28.23	28.29	28.35	28.40	28.46
520	28.52	28.57	28.63	28.69	28.74	28.80	28.86	28.91	28.97	29.02
530	29.08	29.14	29.20	29.25	29.31	29.37	29.42	29.48	29.54	29.59
540	29.65	29.71	29.76	29.82	29.88	29.94	29.99	30.05	30.11	30.16
550	30.22	30.28	30.34	30.39	30.45	30.51	30.57	30.62	30.68	30.74
560	30.80	30.85	30.91	30.97	31.02	31.08	31.14	31.20	31.26	31.31
570	31.37	31.43	31.49	31.54	31.60	31.66	31.72	31.78	31.83	31.89
580	31.95	32.01	32.06	32.12	32.18	32.24	32.30	32.36	32.41	32.47
590	32.53	32.59	32.65	32.71	32.76	32.82	32.88	32.94	33.00	33.06
600	33.11	33.17	33.23	33.29	33.35	33.41	33.46	33.52	33.58	33.64
610	33.70	33.76	33.82	33.88	33.94	33.99	34.05	34.11	34.17	34.23
620	34.29	34.35	34.41	34.47	34.53	34.58	34.64	34.70	34.76	34.82
630	34.88	34.94	35.00	35.06	35.12	35.18	35.24	35.30	35.36	35.42
640	35.48	35.54	35.60	35.66	35.72	35.78	35.84	35.90	35.96	36.02
650	36.08	36.14	36.20	36.26	36.32	36.38	36.44	36.50	36.56	36.62
660	36.69	36.75	36.81	36.87	36.93	36.99	37.05	37.11	37.18	37.24
670	37.30	37.36	37.42	37.48	37.54	37.60	37.66	37.73	37.79	37.85
680	37.91	37.97	38.04	38.10	38.16	38.22	38.28	38.34	38.41	38.47
690	38.53	38.59	38.66	38.72	38.78	38.84	38.90	38.97	39.03	39.09
700	39.15	39.22	39.28	39.34	39.40	39.47	39.53	39.59	39.65	39.72
710	39.78	39.84	39.91	39.97	40.03	40.10	40.16	40.22	40.28	40.35
720	40.41	40.48	40.54	40.60	40.66	40.73	40.79	40.86	40.92	40.98
730	41.05	41.11	41.17	41.24	41.30	41.36	41.43	41.49	41.56	41.62
740	41.68	41.75	41.81	41.87	41.94	42.00	42.07	42.13	42.19	42.26
750	42.32	42.38	42.45	42.51	42.58	42.64	42.70	42.77	42.83	42.90
760	42.96	43.02	43.09	43.15	43.22	43.28	43.35	43.41	43.48	43.54
770	43.60	43.67	43.73	43.80	43.86	43.93	43.99	44.06	44.12	44.18
780	44.25	44.31	44.38	44.44	44.50	44.57	44.63	44.70	44.76	44.82
790	44.89	44.95	45.02	45.08	45.15	45.21	45.28	45.34	45.40	45.47
800	45.53	45.60	45.66	45.72	45.79	45.85	45.92	45.98	46.05	46.11
810	46.18	46.24	46.30	46.37	46.43	46.50	46.56	46.63	46.69	46.76
820	46.82	46.88	46.94	47.01	47.07	47.14	47.20	47.27	47.33	47.39
830	47.46	47.52	47.58	47.65	47.71	47.78	47.84	47.90	47.97	48.03
840	48.09	48.16	48.22	48.28	48.35	48.41	48.48	48.54	48.60	48.66
850	48.73	48.79	48.85	48.92	48.98	49.04	49.10	49.17	49.23	49.29
860	49.36	49.42	49.48	49.54	49.61	49.67	49.73	49.79	49.86	49.92
870	49.98	50.04								

For higher ranges see Page 8.

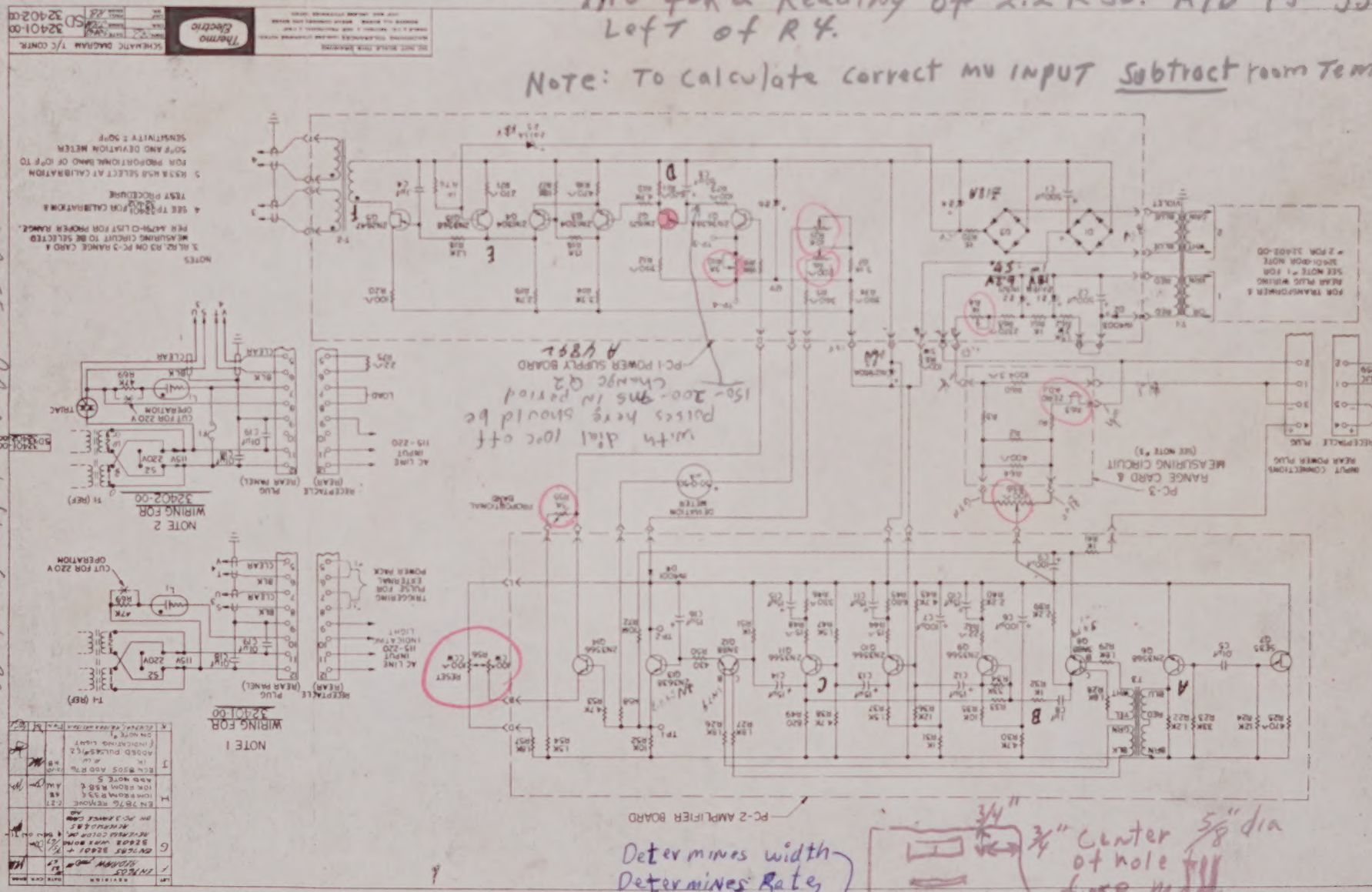
NOTE: Do not Calibrate at EXTREME ends of scale. 50°C & 760°C is OK.

1. Set Low end with Slide wire (1.3V-TP1 TO TP2).
2. Zero meter with R6. (Large Chassis pot at Front end of PC Bd)
3. Set hi end with R4 (Trimpot at Rear end of PC Bd) 1.5V also.
4. Set meter deviation with R21 (Small chassis mounted pot)
5. R10? pull out P/S Board. measure between TP3 & TP4. Adj. R10 for a Reading of 2.2K Ω. R10 is just to Left of R4.

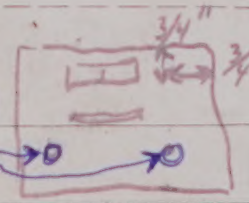
NOTE: To calculate correct MV INPUT Subtract room Temp EMF.

THERMO-ELECTRIC CONTROLLER

R55 PRup—Left front panel
R56 Reset—Right front panel



Determines width
Determines Rate



To A Strip

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